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By H. P. Whitlock.

With One Plate.

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The enormous mass of crystallographic data which have been furnished by investigators of the species calcite since the time of Zippe and Haidinger has resulted in the addition of many new forms to the list available to those critical monographers. Whereas the list of Irby, published in 1878, recognized 156 well established forms, a similar list brought up to date will contain more than twice that number. Faced with this multiplicity of forms, thickly studding the field of gnomonic projection, the modern crystallographic investigator of calcite is ordinarily at a loss to distinguish the common forms from the less common and these again from the rare or unusual ones. It is the purpose of the present paper to furnish a criterion by which the probability of occurrence may be determined for any form, and by an extension of the critical methods, new forms tested.

In the following discussion the method of developing normal series proposed by Dr. Goldschmidt [1] has been adopted as a primary basis of comparison. A brief exposition of Goldschmidt's method of developing normal series is here appended with the object of rendering the analysis more intelligible to the reader.[2]

The mechanical basis of the method of normal series is to be found in the preliminary hypothesis that every face is crystallonomically possible which is perpendicular to a direction of particle attraction. In this way a possible crystal face may be assumed perpendicular to the resultant of any two directions of particle attraction, which is equivalent to saying that every crystal edge may be replaced by a possible crystal face. But, in as much as each mechanical resolution or redivision of the crystallizing forces is accompanied by a weaker

1 Goldschmidt, V., Zeit. f. Kryst., **28**, 1 and 414 (1897).

2 For a short summary of Goldschmidt's article see A. J. Moses, School of Mines Quarterly, **25**, 415 (1904).

tendency toward the production of corresponding crystal faces, the degree of probability for the production of a crystal face in any zone depends directly on the number of times the primary crystallizing forces for that zone have been resolved in order to produce a secondary, tertiary, quaternary, etc., force perpendicular to the given crystal face. If we represent two primary directions of particle-attraction by 0 and ∞ and assume this for the first normal series (N_0) the subsequent results of division and redivision expressed in descending normal series will be:

N_0 0, ∞

N_1 0, 1, ∞

N_2 0, $\frac{1}{2}$, 1, 2, ∞

N_3 0, $\frac{1}{3}$, $\frac{1}{2}$, $\frac{2}{3}$, 1, $\frac{3}{2}$, 2, 3, ∞

N_4 0, $\frac{1}{4}$, $\frac{1}{3}$, $\frac{2}{5}$, $\frac{1}{2}$, $\frac{3}{5}$, $\frac{2}{3}$, $\frac{3}{4}$, 1, $\frac{4}{3}$, $\frac{3}{2}$, $\frac{5}{3}$, 2, $\frac{5}{2}$, 3, 4, ∞

The principles of this method of developing normal series may be then stated as:

1° The probability and therewith the frequency of a number is the greater the nearer the number stands in development to the origin, i. e., the lower the order of the series in which it first occurs.

2° For each derived number and the corresponding form there is a certain intensity. The probability and frequency of a form is the greater the greater its intensity.

Any series representing forms lying in a zone and derived from the crystallographic indices of those forms may be reduced to the series form $0 \ldots \infty$ by the addition of a constant to each number of the series, by multiplication by a constant, by inversion or by remodeling by the formula $\frac{v - v_1}{v_2 - v}$ in which v is any intermediate member in a series, v_1 the first member and v_2 the last member of the series. A zone or zone section when developed by these rules and compared with some member of the normal series N_n may be identical with its normal type, in which case it is probable that this zone or zone section is of normal development and has suffered little or no disturbance. If, on the other hand, such a zone contains terms which do not accord with the normal series such terms invite criticism and should be critically considered from all other points of view, such as zonal intersections, size and definiteness of the faces observed by the author describing them, etc. Such terms are designated "extra" forms and are enclosed in parentheses. Where terms of the normal series N_n are

missing from the developed zone their position is indicated by dots.[3]

It is frequently advisable to divide a zone into fragments, in which case certain points, fixed in the projection by zonal intersections and occupied by the poles of notably frequent and important forms, are taken as the end forms of a series, and are known as " knot points."

No attempt has been made in the discussion to include forms which have been considered by former monographers as doubtful or vicinal as, in the writer's opinion, such an extension of the discussion would not materially add any new light and would unduly cumber the criticism with useless matter.

In many instances throughout the discussion it will be found that forms of comparatively simple indices and reducible to numbers of low normal series are missing from the hitherto observed forms. Where such an obviously probable form occurs in the series, it will be set aside as a hypothetical form, that is, one which will in all probability be ultimately added to the list of observed forms. It has not been considered wise to develop any portion of a zone further than normal series 4— N4, although in tabulating the results at the end of each discussion, a column headed " N5 " has been included.

Knot-points have been assumed at the poles of such obviously common and important forms as φ. $(02\bar{2}1)$, K : $(21\bar{3}1)$, $\mathfrak{p}$: $(13\bar{4}1)$ etc. Using the Knot-points of established zones for poles through which to pass zones subsequently to be discussed and numbering the zones approximately in the order in which they are thus established we have the network of zone intersections shown in Plate 1, which is a gnomonic projection of the field covered by about 80° from the pole of *O* (0001). The zones here shown will be designated throughout the discussion by the letter Z followed by an index; thus zone 6 will be designated by Z_6. The zones shown on Plate 1 are as follows:

3 A brief summary of the critical methods here employed will be found in W. F. Hillebrand and W. T. Schaller, Bull. 405, U. S. Geol. Surv., p. 14 (1909).

Zone	Designation	Limiting poles	Zone equation
Zone 1	Z_1	$[10\bar{1}0 \cdot 11\bar{2}0]$	$[001]$
" 2	Z_2	$[0001 \cdot 11\bar{2}0]$	$[\bar{1}10]$
" 3	Z_3	$[0001 \cdot 10\bar{1}0] \cdot [0001 \cdot 01\bar{1}0]$	$[010]$ $[100]$
" 4	Z_4	$[01\bar{1}2 \cdot 10\bar{1}1] \cdot [10\bar{1}1 \cdot 11\bar{2}0]$	$[\bar{1}21]$ $[\bar{1}11]$
" 5	Z_5	$[10\bar{1}1 \cdot 02\bar{2}1]$ $[02\bar{2}1 \cdot 11\bar{2}0]$	$[\bar{2}\bar{1}2]$ $[\bar{1}1\bar{2}]$
" 6	Z_6	$[02\bar{2}1 \cdot 40\bar{4}1]$ $[40\bar{4}1 \cdot 11\bar{2}0]$	$[\bar{1}24]$ $[\bar{1}14]$
" 7	Z_7	$[40\bar{4}1 \cdot 08\bar{8}1]$	$[\bar{2}\bar{1}8]$
" 8	Z_8	$[10\bar{1}4 \cdot 01\bar{1}2]$ $[01\bar{1}2 \cdot 11\bar{2}0]$	$[\bar{4}\bar{2}1]$ $[\bar{2}2\bar{1}]$
" 9	Z_9	$[10\bar{1}2 \cdot 01\bar{1}1]$ $[01\bar{1}1 \cdot 11\bar{2}0]$	$[\bar{2}\bar{1}1]$ $[\bar{1}1\bar{1}]$
" 10	Z_{10}	$[0\bar{5}51 \cdot 10 \cdot 0 \cdot \bar{1}\bar{0} \cdot 1]$	$[1 \cdot 2 \cdot \bar{1}\bar{0}]$
" 11	Z_{11}	$[50\bar{5}2 \cdot 05\bar{5}1]$	$[21\bar{5}]$
" 12	Z_{12}	$[05\bar{5}4 \cdot 50\bar{5}2]$	$[24\bar{5}]$
" 13	Z_{13}	$[07\bar{7}2 \cdot 70\bar{7}1]$	$[12\bar{7}]$

The arbitrary rulings by which "extra" forms are adjudged "well established," "probable," "doubtful" etc., are briefly:

1° The normal series in which the form first appears.

2° Its relation to other and well established forms of the calcite form system as established by zonal relations.

3° The author's description of the form, whether curved, dull, sharply defined, etc.

Zone 1 — Dihexagonal Prisms. Symbol $\frac{k}{h}$.

Using Bravais-Miller indices and suppressing the third term, the prism zone is as follows:

Form	b 100	Ψ 10·1·0	σ 710	ξ 310	θ 210	μ 530	j 760	a 110
Symbol	0	$\frac{1}{10}$	$\frac{1}{7}$	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{3}{5}$	$\frac{6}{7}$	1
$\frac{v}{1-v}$	0	$\frac{1}{9}$	$\frac{1}{6}$	$\frac{1}{2}$	1	$\frac{3}{2}$	6	∞
N_3	0	$(\frac{1}{9})$	$(\frac{1}{6})$ ·	$\frac{1}{2}$ ·	1	$\frac{2}{3}$ ··	(6)	∞

Referred to N_3 the zone is incomplete and contains the extra forms $\frac{1}{10}$, $\frac{1}{7}$ and $\frac{6}{7}$. Of these the two last belong in normal series $6 = N_6$ and the first, $\frac{1}{10}$, seems to be doubtful.

Ψ $(10\cdot1\cdot\bar{1}1\cdot0)$. This prism was observed by Schnorr [4] on material from Neumark, Germany. It lies in zone [0001:10·1·$\bar{1}1$·3:40·4·$\bar{4}4$·9:10·1·$\bar{1}1$·0]; the two intermediate forms $(10\cdot1\cdot\bar{1}1\cdot3)$ and $(40\cdot4\cdot\bar{4}4\cdot9)$ were observed by Palache [5] on crystals from Lake Superior and seem rational and well established.

σ $(71\bar{8}0)$. This prism was observed by Whitlock [6] on crystals from Bergen Hill, N. J. It lies in a vertical zone containing $(71\bar{8}9)$, $(71\bar{8}6)$ and $(14\cdot2\cdot\bar{1}6\cdot3)$ and also in the very well marked zone [1$\bar{1}$02·17$\bar{8}$0] containing no less than 13 intermediate forms. The form is probable.

j $(7\cdot6\cdot\bar{1}3\cdot0)$. This prism was observed by Schaller [7] on crystals from Andreasberg. It lies in the vertical zone which contains the forms $(14\cdot12\cdot\bar{2}6\cdot5)$ and $(7\cdot6\cdot\bar{1}3\cdot2)$. On the whole this form seems less probable than either of the two preceding ones.

Hypothetical Prism. Referring to N_2 in the above development, it will be noted that the term 2, corresponding to $\frac{1}{2}$, is absent from the series. The hypothetical prism which would yield 2 in this series would have the indices $(32\bar{5}0) = \infty$ R5. Although not strongly marked the vertical zone [0001·32$\bar{5}$0] contains the forms $(32\bar{5}7)$, $(32\bar{5}4)$ and $(32\bar{5}1)$.

Zone 2 — Pyramids of the Second Order. Symbol $\frac{h}{l}$.

Using the Bravais-Miller indices and suppressing the third term, the zone of the second order pyramids contains the following forms:

Form	o 001	π 113	χ 7·7·12	λ 223	υ 111	α 443	ω 16·16·9
Symbol	0	$\frac{1}{3}$	$\frac{7}{12}$	$\frac{2}{3}$	1	$\frac{4}{3}$	$\frac{16}{9}$
$\frac{3-v}{4}$	0	$\frac{1}{4}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$\frac{4}{3}$
N_4	0	$\frac{1}{4}$ ·	$(\frac{7}{16})$	$\frac{1}{2}$ ··	$\frac{3}{4}$	1	$\frac{4}{3}$

Form	ξ 221	β 773	γ 883	δ 331	ϵ 441	η 551	φ 881	a 110
Symbol	2	$\frac{7}{3}$	$\frac{8}{3}$	3	4	5	8	∞
$\frac{3-v}{4}$	$\frac{3}{2}$	$\frac{7}{4}$	2	$\frac{9}{4}$	3	$\frac{15}{4}$	6	∞
N_4	$\frac{3}{2}$ ·	$(\frac{7}{4})$	2	$(\frac{9}{4})$	3	$(\frac{15}{4})$ ·	(6)	∞

4 Schnorr, Programm d. Realgym. Z. Zwickau, p. 6 (1896).
5 Palache, C., Geol. Surv. Mich., **6**, 161 (1900).
6 Whitlock, H. P., N. Y. State Mus. Bull., 133, p. 217.
7 Schaller, W. T., Zeit. f. Kryst., **44**, 321 (1908).

Referred to N_4 the zone is incomplete and contains the extra forms of $\frac{7}{12}$, $\frac{7}{13}$, 3, 5 and 8.

χ $(7\cdot7\cdot\bar{1}4\cdot12)$. This pyramid was noted with the indices $(5\cdot5\cdot\bar{1}0\cdot9)$ by Hessenberg [8] on crystals from Maderaner Thal. According to Irby,[9] Hessenberg's material was later shown to be dolomite from Binnenthal. The present indices were substituted by Descloizeaux [10] for those of Hessenberg. The form must be regarded as quite doubtful.

β $(7\cdot7\cdot\bar{1}4\cdot3)$. This is also a rare pyramid. It is shown in combination in Fig. 51 of Zippe's [11] monograph where it is mentioned as of uncertain authority. It lies, however, at the intersection of the zones Z_{13} and $[\bar{5}7\bar{2}3\cdot10\bar{1}0]$ both of which are well marked. Moreover the term $\frac{7}{4}$ is referable to normal series N_5. The form seems to be fairly probable.

δ $(33\bar{6}1)$. This pyramid is given by Hauy [12] as occurring on crystals from Derbyshire and Andreasberg. Zippe also shows a combination (Fig. 50) from Andreasberg. On none of these figures, where the zonal relations are susceptible of being checked by the drawing, does the pyramid shown correspond to $(33\bar{6}1)$, and in fact the drawing of Zippe would make the pyramid in question $(5\cdot5\cdot\bar{1}0\cdot1)$. $(33\bar{6}1)$ was also noted by Sansoni [13] on a combination from Andreasberg. Sansoni's measured angles do not accord well with theory, there being an average difference of $1\frac{1}{2}°$ between adjacent polar angles. The form seems to be rather unprobable.

η $(5\cdot5\cdot\bar{1}0\cdot1)$. This pyramid was observed by Rogers [14] on crystals from Frizington, England. It lies at the intersection of the well marked zones $[5\bar{5}02\cdot3\bar{1}21]$ and $[50\bar{5}1\cdot5\bar{5}01]$. The form seems to be fairly probable.

φ $(8\cdot8\cdot\bar{1}6\cdot1)$. This pyramid was recorded by Whitlock [15] on crystals from Sommerville, N. Y. The zonal relations of this form are not so good as those of $(5\cdot5\cdot\bar{1}0\cdot1)$ although it constitutes the limiting member of the series $(11\bar{2}1)$, $(22\bar{4}1)$, $44\bar{8}1)$, $(8\cdot8\cdot\bar{1}6\cdot1)$. On the whole this pyramid seems less probable than the preceding one and of about the same degree of probability as $(33\bar{6}1)$.

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8 Hessenberg, F., Min. Notiz., **4**, Frankfurt (1861).
9 Irby, J. R. Mc. D., Inaug-Disser., Goettingen (1878).
10 Descloizeaux, A., Manuel de Min., Paris (1874).
11 Zippe, F. X. M., Akad. d. Wiss. Wien. Math.-naturwiss. Cl., **3** (1852).
12 Hauy, Traité de Mineralogie Paris, Figs. 4, 72, 144, 152 (1822).
13 Sansoni, F., R. Accad. d. Linc., **19** (1884).
14 Rogers, A. F., Am. Jour. Sci., **12**, 44 (1901).
15 Whitlock, H. P., N. Y. State Mus. Memoir, **13**, p. 74 (1910).

Hypothetical Pyramids. The only two members missing from normal series N_3 in the above development are $\frac{1}{3}$ and $\frac{2}{3}$ corresponding respectively to $(44\bar{8}9)$ and $(8\cdot8\cdot\bar{1}6\cdot9)$.

$(44\bar{8}9) = (73_1)$. Parallel zones through the poles of this form do not pass through the poles of common forms or of those whose indices

Letter	Symbol	Knot	N_1	N_2	N_3	N_4	N_5	?	Zone intersections
Zone 1 = Z_1 Dihexagonal Prisms									
Ψ	$10\cdot1\cdot\bar{1}\bar{1}\cdot0$							?	
σ	$71\bar{8}0$							?	
ξ	$31\bar{4}0$			N_2					
θ	$21\bar{3}0$		N_1						
μ	$53\bar{8}0$				N_3				
j	$7\cdot6\cdot\bar{1}3\cdot0$							?	
Hypothetical Prism									
	$32\bar{5}0$			N_2					
Zone 2 = Z_2 Pyramids of the Second Order									
π	$11\bar{2}3$					N_4			Z_4, Z_9
χ	$7\cdot7\cdot14\cdot12$							?	
λ	$22\bar{4}3$			N_2					Z_5
υ	$11\bar{2}1$					N_4			
α	$44\bar{8}3$		N_1						Z_6
ω	$16\cdot16\cdot\bar{3}\bar{2}\cdot9$					N_4			
ξ	$22\bar{4}1$				N_3				
β	$7\cdot7\cdot1\bar{4}\cdot3$						N_5		Z_{13}
γ	$8\cdot8\cdot\bar{1}6\cdot3$			N_2					Z_7
δ	$33\bar{6}1$							?	
ϵ	$44\bar{8}1$				N_3				
η	$5\cdot5\cdot\bar{1}0\cdot1$							?	
φ	$8\cdot8\cdot\bar{1}6\cdot1$							?	

are sufficiently simple to mark such zones in any way. The form as a hypothetical one should be rejected.

$(8\cdot 8\cdot \bar{1}\bar{6}\cdot 9) = (11\cdot 3\cdot 5)$. This hypothetical pyramid like the preceding one should be rejected, for the reasons given above.

Zone 3 — Positive Rhombohedrons.

Symbol $\frac{h}{l}$.

The most prominent forms in the zone of the positive rhombohedrons are $(10\bar{1}1)$ and $40\bar{4}1)$. These forms should certainly be regarded as knot points. Between $(40\bar{4}1)$ and $(10\bar{1}0)$ the two most prominent zone intersections are $(70\bar{7}1)$ and $(13\cdot 0\cdot \bar{1}\bar{3}\cdot 1)$, both fairly common forms. Dividing the zone in this way we have for the first portion:

Form	$\left\{\begin{matrix} o \\ 001 \end{matrix}\right.$	$d.$ 104	$e.$ 205	$f.$ 102	$g.$ 407	$h.$ 203	$V.$ 405	$p.$ 101
Symbol	0	$\frac{1}{4}$	$\frac{2}{5}$	$\frac{1}{2}$	$\frac{4}{7}$	$\frac{2}{3}$	$\frac{4}{5}$	1
$\frac{v}{1-v}$	0	$\frac{1}{3}$	$\frac{2}{3}$	1	$\frac{4}{3}$	2	4	∞
N_3	0	$\frac{1}{3}$ ·	$\frac{2}{3}$	1	$(\frac{4}{3})$ ·	2 ·	(4)	∞

Referring this series to N_3 the series is incomplete and contains the extra forms $\frac{4}{7}$ and $\frac{4}{5}$ both of which would fall in normal series N_4.

g. $(40\bar{4}7)$. This rhombohedron was observed by Hessenberg (loc. cit.) on crystals from Maderaner Thal; it had previously been regarded by Zippe[16] as doubtful. As pointed out under χ $(7\cdot 7\cdot \bar{1}\bar{4}\cdot 12)$[17] Hessenberg's specimen proved to be dolomite from Binnenthal. The form in question lies in the zone $[1\bar{1}02\cdot 17\bar{8}0]$ as well as in two less well marked zones and may be regarded as fairly probable.

V $(40\bar{4}5)$. This rhombohedron was observed by Sterrett[18] on twinned crystals from the Joplin region. Although the form was noted on a number of crystals, in the instance of only one crystal could reflections be obtained. The form seems less probable than $(40\bar{4}7)$.

The forms between $(10\bar{1}1)$ and $(40\bar{4}1)$ are:

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16 Zippe, loc. cit.
17 See page 294.
18 Sterrett, D. B., Am. Jour. Sci., **18**, 73 (1904).

Form	$p.$ 101	$R.$ 201	$K.$ 502	$l.$ 301	$m.$ 401
Symbol	1	2	$\frac{5}{2}$	3	4
$\frac{v-v_1}{v_2-v}$	0	$\frac{1}{2}$	1	2	∞
N_2	0	$\frac{1}{2}$	1	2	∞

This portion of the zone is entirely normal.

The forms between $(40\bar{4}1)$ and $(70\bar{7}1)$ are:

Form	$m.$ 401	$n.$ 501	$o.$ $11\cdot0\cdot2$	$y.$ 601	$x.$ $13\cdot0\cdot2$	$q.$ 701
Symbol	4	5	$\frac{11}{2}$	6	$\frac{13}{2}$	7
$\frac{v-v_1}{v_2-v}$	0	$\frac{1}{2}$	1	2	5	∞
N_2	0	$\frac{1}{2}$	1	2	(5)	∞

Referred to N_2 this portion of the zone is complete and contains the extra form 7 which would fall in normal series N_5.

$x.$ $(13\cdot0\cdot\bar{1}\bar{3}\cdot2)$. This rhombohedron was observed by Höfer [19] on crystals from Rauris in Salzburg. On the same occurrence the same author has found the negative rhombohedron $(0\cdot13\cdot\bar{1}\bar{3}\cdot1)$, thus emphasizing the zone $[13\cdot0\cdot\bar{1}\bar{3}\cdot2 : 0\cdot13\cdot\bar{1}\bar{3}\cdot1]$ which also contains the forms $(61\bar{7}1)$ and $(16\cdot7\cdot\bar{2}\bar{3}\cdot3)$. The zone $[0\cdot13\cdot\bar{1}\bar{3}\cdot4 : 13\cdot0\cdot\bar{1}\bar{3}\cdot2]$ is also well marked. The form seems quite probable.

The forms between $(70\bar{7}1)$ and $(13\cdot0\cdot\bar{1}\bar{3}\cdot1)$ are:

Form	$q.$ 701	$c.$ 801	$b.$ 901	$r.$ $10\cdot0\cdot1$	$k.$ $11\cdot0\cdot1$	$s.$ $13\cdot0\cdot1$
Symbol	7	8	9	10	11	13
$\frac{v-v_1}{v_2-v}$	0	$\frac{1}{5}$	$\frac{1}{2}$	1	2	∞
N_2	0	$(\frac{1}{5})$	$\frac{1}{2}$	1	2	∞

Referred to N_2 this portion of the zone is complete, the form 8 being extra and falling in normal series N_5.

$c.$ $(80\bar{8}1)$. This rhombohedron was found by Cesàro [20] on crystals from Rhisnes, Belgium. It is included among the doubtful forms in Rogers [21] list. The fact that the zone $[04\bar{4}1\cdot80\bar{8}1]$ is exceptionally

19 Höfer, H., Min. Mitth., **12**, 487 (1891).
20 Cesàro, G., Soc. Geol. Belg. Ann., **16**, 165 (1889).
21 Rogers, A. F., S. of M. Quar., **22**, 429 (1901).

well marked, containing at least four poles of well established forms, would seem to remove any doubt as to the validity of this form.

Between $(13\cdot0\cdot\bar{1}\bar{3}\cdot1)$ and $(10\bar{1}0)$ the forms are:

Form	s. $13\cdot0\cdot1$	$t\cdot$ $16\cdot0\cdot1$	$v\cdot$ $18\cdot0\cdot1$	$w\cdot$ $19\cdot0\cdot1$	i· $20\cdot0\cdot1$
Symbol	13	16	18	19	20
$\frac{v-13}{9}$	0	$\frac{1}{3}$	$\frac{5}{9}$	$\frac{2}{3}$	$\frac{7}{9}$
N_4	0 .	$\frac{1}{3}$ ..	$(\frac{5}{9})$.	$\frac{2}{3}$	$(\frac{7}{9})$.

Form	$Z\cdot$ $22\cdot0\cdot1$	c· $24\cdot0\cdot1$	j. $25\cdot0\cdot1$	$z\cdot$ $28\cdot0\cdot1$	b 100
Symbol	22	24	25	28	∞
$\frac{v-13}{9}$	1	$\frac{11}{9}$	$\frac{4}{3}$	$\frac{5}{3}$	∞
N_4	1	$(\frac{11}{9})$	$\frac{4}{3}$.	$\frac{5}{3}$	∞

Referred to N_4 this portion of the zone is incomplete and contains the extra forms 18, 20, and 24.

v. $(18\cdot0\cdot\bar{1}\bar{8}\cdot1)$. This rhombohedron was observed by vom Rath [22] on crystals from Lake Superior and subsequently by von Foullon [23] on crystals from Arlsberg. Goldschmidt [24] regards both observations as doubtful and substitutes the form $(19\cdot0\cdot\bar{1}\bar{9}\cdot1)$ as both conforming better with the rhombohedral series and agreeing more closely with the recorded measurements.

i. $(20\cdot0\cdot\bar{2}\bar{0}\cdot1)$. Sansoni [25] records this rhombohedron from St. Blasien, Baden. The form is very close to $(22\cdot0\cdot\bar{2}\bar{2}\cdot1)$ which is recorded by the same authority from a neighboring locality, under what appears to be similar conditions. The form is quite doubtful.

c. $(24\cdot0\cdot\bar{2}\bar{4}\cdot1)$. This rhombohedron was observed by Hobbs [26] on crystals from Mineral Point, Wis. The form was identified from one series of measurements, the difference in calculated angle between $(24\cdot0\cdot\bar{2}\bar{4}\cdot1)$ and $(22\cdot0\cdot\bar{2}\bar{2}\cdot1)$ being 14′. It is possible that the observed form should have been referred to the simpler indices.

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22 vom Rath, G., Pogg. Ann., **132**, 387 (1867).
23 von Foullon, H., Jahrb. geol. Reichs. Wein, **35**, 47.
24 Goldschmidt, V., Index der Krystallformen, **1**, 378 (1886).
25 Sansoni, F., Gior. d. Min., **1**, 299 (1890).
26 Hobbs, W. H., Univ. Wis. Sci. Ser. Bull., **1**, 115 (1895).

Hypothetical Positive Rhombohedrons.

The zone of the positive rhombohedrons is singularly free, particularly in that position between $(10\bar{1}1)$ and $(13\cdot0\cdot\bar{1}3\cdot1)$. In the portion

Zone 3 = Z_3 Positive Rhombohedrons

Letter	Symbol	Knot	N_1	N_2	N_3	N_4	N_5	?	Zone intersections
z·	$28\cdot0\cdot\bar{2}8\cdot1$					N_4			
j·	$25\cdot0\cdot\bar{2}5\cdot1$					N_4			
c·	$24\cdot0\cdot\bar{2}4\cdot1$							?	
Z·	$22\cdot0\cdot\bar{2}2\cdot1$		N_1						
i·	$20\cdot0\cdot\bar{2}0\cdot1$							?	
w·	$19\cdot0\cdot\bar{1}9\cdot1$				N_3				
v·	$18\cdot0\cdot\bar{1}8\cdot1$							?	
t·	$16\cdot0\cdot\bar{1}6\cdot1$				N_3				
s·	$13\cdot0\cdot\bar{1}3\cdot1$	×							
k·	$11\cdot0\cdot\bar{1}1\cdot1$			N_2					
r·	$10\cdot0\cdot\bar{1}0\cdot1$		N_1						Z_{10}
b·	$90\bar{9}1$			N_2					
c·	$80\bar{8}1$						N_5		
q·	$70\bar{7}1$	×							Z_{13}
x·	$13\cdot0\cdot\bar{1}3\cdot2$						N_5		
y·	$60\bar{6}1$			N_2					
o·	$11\cdot0\cdot\bar{1}1\cdot2$		N_1						
n·	$50\bar{5}1$			N_2					
m·	$40\bar{4}1$	×							Z_5, Z_6
l·	$30\bar{3}1$			N_2					
K·	$50\bar{5}2$		N_1						Z_{11}, Z_{12}
R·	$20\bar{2}1$			N_2					
p·	$10\bar{1}1$	×							Z_4, Z_5
V·	$40\bar{4}5$					N_4			
h·	$20\bar{2}3$			N_2					
g·	$40\bar{4}7$					N_4			
f·	$10\bar{1}2$		N_1						Z_9
e·	$20\bar{2}5$				N_3				
d·	$10\bar{1}4$				N_3				Z_8

between $(13\cdot0\cdot\bar{1}\bar{3}\cdot1)$ and $(10\bar{1}0)$ the missing members of normal series N_2, i. e. $\frac{1}{2}$ and 2, would develop from the highly improbable hypothetical forms $(35\cdot0\cdot\bar{3}\bar{5}\cdot2)$ and $(31\cdot0\cdot\bar{3}\bar{1}\cdot1)$ respectively.

Zone 3 — Negative Rhombohedrons. Symbol $\frac{k}{\bar{l}}$.

The most prominent forms of the negative rhombohedrons are unquestionably $(01\bar{1}2)$ and $(02\bar{2}1)$. Assuming these poles as knots we have in the portion of the zone between (0001) and $01\bar{1}2$):

Form	o	α	β.	γ.	s.
	0001	015	0·7·20	025	012
Symbol	0	$\frac{1}{5}$	$\frac{7}{20}$	$\frac{2}{5}$	$\frac{1}{2}$
$\frac{v}{v_2 - v}$	0	$\frac{2}{3}$	$\frac{7}{3}$	4	∞
$\frac{v^1}{2}$	0	$\frac{1}{3}$	$\frac{7}{6}$	2	∞
N_3	0	$\frac{1}{3}$ ···	$(\frac{7}{6})$ ·	2 ·	∞

This portion of the zone is incomplete and contains the extra form $\frac{7}{20}$.

β. $(0\cdot7\cdot\bar{7}\cdot20)$. This rhombohedron was recorded by Lévy[27] on crystal from Offenbanya, Hungary, and later by Peters[28] on a combination from Kapnik, Hungary. Peters did not compare the angle observed on this form with the calculated angle corresponding to $(0\cdot7\cdot\bar{7}\cdot20)$ and a simple calculation will show that his measured angle corresponds more closely to $(02\bar{2}5)$ than to the assumed indices. The form is doubtful.

Hypothetical Rhombohedrons. Referring the above series to N_2 the terms $\frac{1}{2}$ and 1 are missing. The hypothetical negative rhombohedrons corresponding to these members of the series are $(01\bar{1}4)$ and $(01\bar{1}3)$ respectively.

$(01\bar{1}4) = (552)$. The zones $[01\bar{1}4\cdot10\bar{1}0]$ and $[01\bar{1}4\cdot11\bar{2}0]$ although not well marked contain several rational and well established forms. The form should be retained as hypothetical.

$(01\bar{1}3) = (441)$. The zone $[01\bar{1}3\cdot10\bar{1}0]$ passes through the poles of $(11\bar{2}2)$, $(52\bar{7}6)$, $(41\bar{5}3)$, $(10\cdot1\cdot\bar{1}\bar{1}\cdot3)$, etc. The form should be retained as hypothetical.

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27 Levy, A., London (1837).
28 Peters, C. F., Neues Jahrb. Min., **7861**, 434.

The portion of the zone between $(01\bar{1}2)$ and $(02\bar{2}1)$ is extremely rich in forms, no less than 28 rhombohedrons having been recorded between these limits. Prominent zone intersections occur at $(01\bar{1}1)$ and $(03\bar{3}2)$, which suggest these poles as knot points. Splitting at these points, the forms in the first portion are:

Form	$\delta\cdot$ 012	$\mathfrak{a}\cdot$ 0·11·20	$\epsilon\cdot$ 035	$\varsigma\cdot$ 023	$\mathfrak{b}\cdot$ 0·18·25	$S\cdot$ 0·11·14
Symbol	$\frac{1}{2}$	$\frac{11}{20}$	$\frac{3}{5}$	$\frac{2}{3}$	$\frac{18}{25}$	$\frac{11}{14}$
$\frac{v-v_1}{v_2-v}$	0	$\frac{1}{9}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{11}{14}$	$\frac{4}{3}$
N_3	·0	$(\frac{1}{9})$	$\frac{1}{4}$ ..	$\frac{1}{2}$ ...	$(\frac{11}{14})$.	$\frac{4}{3}$

Form	$\eta\cdot$ 045	$\mathfrak{v}\cdot$ 0·14·17	$\theta\cdot$ 078	$D\cdot$ 0·19·20	$\kappa\cdot$ 011
Symbol	$\frac{4}{5}$	$\frac{14}{17}$	$\frac{7}{8}$	$\frac{19}{20}$	1
$\frac{v-v_1}{v_2-v}$	$\frac{3}{2}$	$\frac{11}{6}$	3	9	∞
N_3	$\frac{3}{2}$.	$(\frac{11}{6})$ ..	3 .	(9)	∞

This portion of the zone is incomplete and contains the extra forms $\frac{1}{9}$, $\frac{11}{14}$, $\frac{11}{6}$ and 9. Of these the first and last are obviously extremely close to the knots and might possibly have been due to vicinal development.

$\mathfrak{a}$. $(0\cdot11\cdot\bar{1}\bar{1}\cdot20)$. This rhombohedron was observed by Hobbs[29] on calcite crystals from southern Wisconsin. Prof. Hobbs in discussing this form suggests that it may be due to corrosion.

$\mathfrak{b}$. $(0\cdot18\cdot\bar{1}\bar{8}\cdot25)$. This rhombohedron was also observed by Hobbs[29] on the afore mentioned occurrence. It is worthy of note that the hypothetical rhombohedron $(0\cdot13\cdot\bar{1}\bar{3}\cdot18)$, which reduces to $\frac{4}{5}$ in the above series comes 5′ nearer to the measured angle as given by Hobbs. The form is doubtful.

$\mathfrak{v}$. $(0\cdot14\cdot\bar{1}\bar{4}\cdot17)$. This rhombohedron was noted by Schaller[30] on crystals from Hillsboro, New Mexico. The form, which was established from 3 measurements with the two circle gonimeter, seems more rational than any other of the extra forms in the series. The hypothetical rhombohedron $(05\bar{5}6)$ which would reduce to 2 in the normal

29 Hobbs, W. N., loc. cit.
30 Schaller, W. T., loc. cit.

series lies 10′ further from the pole of the form as measured than the indices $(0\cdot14\cdot\bar{1}4\cdot17)$ assigned to it by Schaller.

D. $(0\cdot19\cdot\bar{1}9\cdot20)$. This rhombohedron was observed by Cesàro[31] on crystals from Arquennes, Belgium. It lies close to $(01\bar{1}1)$, a form noted by the same authority on several combinations from Rhisnes. It should be referrred to the simpler indices.

Hypothetical Rhombohedrons.— The two members missing from normal series N_2 in the above development are 1 and 2 corresponding respectively to $(03\bar{3}4)$ and $(05\bar{5}6)$. Parallel zones through the poles of these hypothetical forms, do not suggest any simple zonal relations between them and common and well established forms. The forms as hypothetical ones should be rejected.

The portion of the zone between $(01\bar{1}1)$ and $(03\bar{3}2)$ contains the following forms:—

Form	$\kappa\cdot$ 011	$\mathfrak{h}\cdot$ 0·17·16	$\lambda\cdot$ 087	$\mu\cdot$ 065	$\nu\cdot$ 054	$G\cdot$ 0·14·11
Symbol	1	$\frac{17}{16}$	$\frac{8}{7}$	$\frac{6}{5}$	$\frac{5}{4}$	$\frac{14}{11}$
$\frac{v-v_1}{v_2-v}$	0	$\frac{1}{7}$	$\frac{2}{5}$	$\frac{2}{3}$	1	$\frac{6}{5}$
$\frac{v^1}{2}$	0	$\frac{1}{14}$	$\frac{1}{5}$	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{3}{5}$
N_4	0	$(\frac{1}{14})$	$(\frac{1}{5})$	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{3}{5}$

Form	$\xi\cdot$ 043	$H\cdot$ 0·18·13	$\pi\cdot$ 075	$P\cdot$ 0·13·9	$Y\cdot$ 0·19·13	$\rho\cdot$ 032
Symbol	$\frac{4}{3}$	$\frac{18}{13}$	$\frac{7}{5}$	$\frac{13}{9}$	$\frac{19}{13}$	$\frac{3}{2}$
$\frac{v-v_1}{v_2-v}$	2	$\frac{10}{3}$	4	8	12	∞
$\frac{v^1}{2}$	1	$\frac{5}{3}$	2	4	6	∞
N_4	1	$\frac{5}{3}$	2	4	(6)	∞

This portion of the zone is incomplete and contains the extra forms $\frac{17}{16}$, $\frac{8}{7}$ and $\frac{19}{13}$.

$\mathfrak{h}$. $(0\cdot17\cdot\bar{1}7\cdot16)$. This rhombohedron was observed by Cesàro[32] on crystals from Rhisnes, Belgium. It lies close to $(01\bar{1}1)$ and, like $(0\cdot19\cdot\bar{1}9\cdot20)$ from Arquennes, should possibly be referred to the simpler indices.

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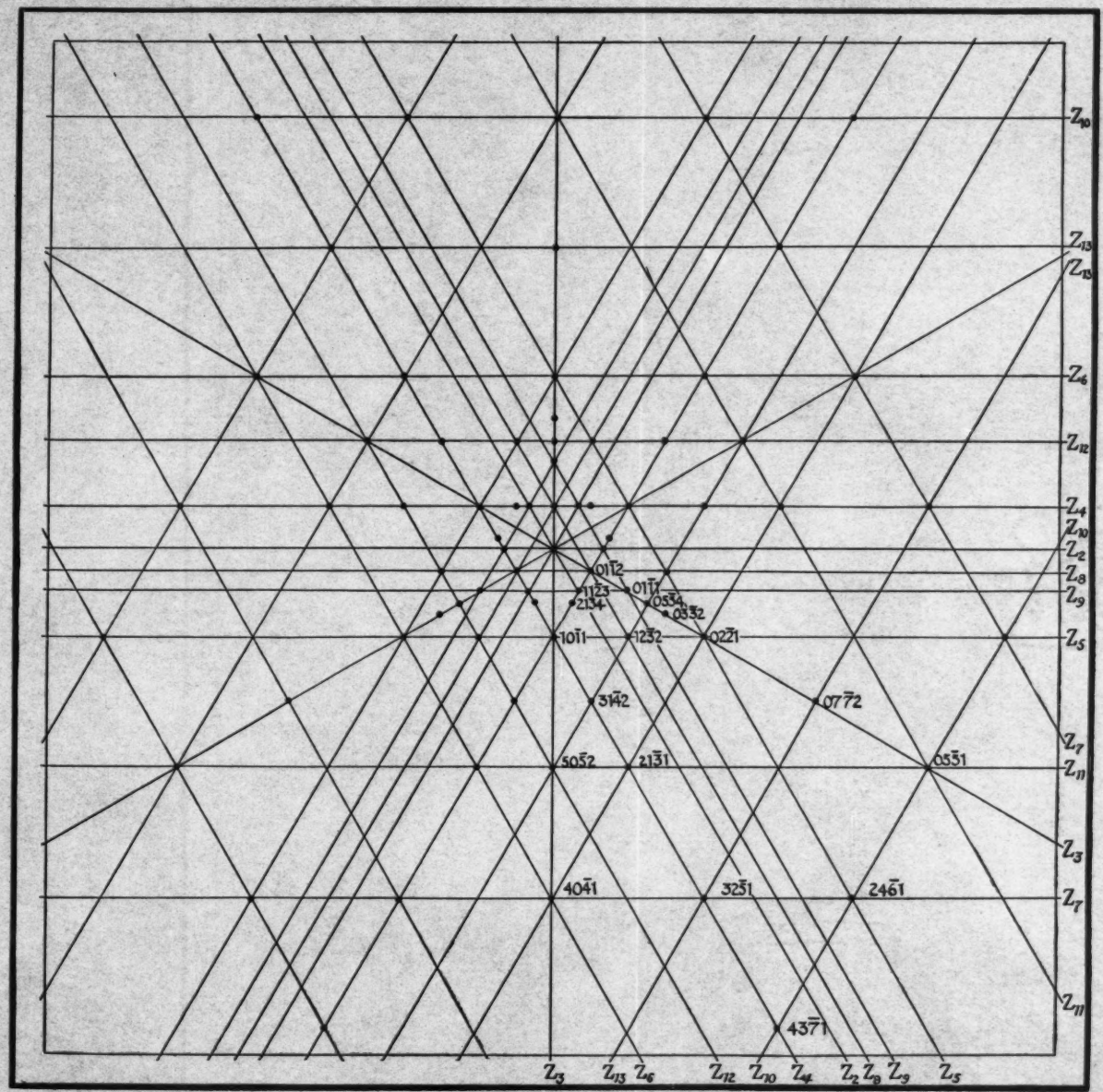
31 Cesàro, G., loc. cit.
32 Cesàro, G., loc. cit.


Z_{10}
Z_{13}
Z_{15}
Z_4
Z_{12}
Z_4
Z_{10}
Z_2
Z_8
Z_9
Z_5
Z_7
Z_{11}
Z_3
Z_7
Z_{11}
$01\bar{1}2$
$11\bar{2}3$
$01\bar{1}1$
2134
$05\bar{3}4$
$08\bar{3}2$
$10\bar{1}1$
$12\bar{3}2$
$02\bar{2}1$
$31\bar{4}2$
$07\bar{7}2$
$50\bar{5}2$
$21\bar{3}1$
$05\bar{3}1$
$40\bar{4}1$
$32\bar{5}1$
$24\bar{6}1$
$43\bar{7}1$
Z_3 Z_{13} Z_6 Z_{12} Z_{10} Z_4 Z_2 Z_8 Z_9 Z_5

λ. $(08\bar{8}7)$. This rhombohedron was first observed by Zippe[33] on crystals from Andreasberg. It was subsequently noted by Hessenberg[34] and Sansoni[35] on several combinations from the same locality. It also marks the intersection of the zone $[08\bar{8}7 \cdot 11\bar{2}0]$ which contains a number of well established forms. The form should be regarded as well established.

Y. $(0 \cdot 19 \cdot \bar{1}9 \cdot 13)$. This rhombohedron was observed by Whitlock[36] on crystals from Lyon Mountain, N. Y. The form occurs on two of the five types described, and on one of them (Type II) is developed to the extent of a dominant habit. It lies close to $(03\bar{3}2)$ and should be regarded as somewhat doubtful.

The following rhombohedrons lie in the portion of the zone between $(03\bar{3}2)$ and $(02\bar{2}1)$:

Form	ρ. 032	σ. 0·11·7	f. 085	τ 0·13·8	L. 053	M. 074	A. 095	N. 0·11·6	φ. 021
Symbol	$\frac{2}{3}$	$\frac{11}{7}$	$\frac{8}{5}$	$\frac{13}{8}$	$\frac{5}{3}$	$\frac{7}{4}$	$\frac{9}{5}$	$\frac{11}{6}$	2
$\frac{v - v_1}{v_2 - v}$	0	$\frac{1}{6}$	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{1}{2}$	1	$\frac{3}{2}$	2	∞
$2v'$	0	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{2}{3}$	1	2	3	4	∞
N_3	0	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{2}{3}$	1	2	3	(4)	∞

Referred to N_3 this portion of the zone is nearly complete and contains the extra form $\frac{11}{6}$ which would fall in normal series N_4.

N. $(0 \cdot 11 \cdot \bar{1}\bar{1} \cdot 6)$. This rhombohedron was noted by Thurling[37] on crystals from Andreasberg. The form was established from good measurements in the rhombohedral zone. The zone $[0 \cdot 11 \cdot \bar{1}\bar{1} \cdot 6 : 10\bar{1}0]$ is well defined and the form, which occurs in normal series N_4, may be said to be fairly well established.

In the portion of the zone lying between $(02\bar{2}1)$ and $01\bar{1}0)$ the most prominent zone intersections occur at $(05\bar{5}1)$ and $(0 \cdot 11 \cdot \bar{1}\bar{1} \cdot 1)$ Splitting the zone at these points as knots we have for the zone fragment between $(02\bar{2}1)$ and $05\bar{5}1)$:

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33 Zippe, F. X. M., loc. cit., Fig. 90.
34 Hessenberg, F., loc. cit.
35 Sansoni, F. R., loc. cit.
36 Whitlock, H. P., N. Y. State Mus. Mem., **13**, 81 (1910).
37 Thürling, G., N. Jahrb. f. Min. B. B., **4**, 327 (1886).

Form	$\varphi\cdot 021$	$\chi\cdot 094$	$F\cdot 0\cdot12\cdot5$	$\Psi\cdot 052$	$\omega\cdot 0\cdot11\cdot4$	$\Gamma\cdot 031$
Symbol	2	$\frac{9}{4}$	$\frac{12}{5}$	$\frac{5}{2}$	$\frac{11}{4}$	3
$\frac{v-v_1}{v_2-v}$	0	$\frac{1}{11}$	$\frac{2}{13}$	$\frac{1}{5}$	$\frac{1}{3}$	$\frac{1}{2}$
N_3	0	$(\frac{1}{11})$	$(\frac{2}{13})$	$(\frac{1}{5})$	$\frac{1}{3}$	$\frac{1}{2}$

Form	$\vartheta\cdot 0\cdot16\cdot5$	$J\cdot 0\cdot13\cdot4$	$\Delta\cdot 072$	$\Theta\cdot 041$	$\Lambda\cdot 092$	$\Xi\cdot 051$
Symbol	$\frac{16}{5}$	$\frac{13}{4}$	$\frac{7}{2}$	4	$\frac{9}{2}$	5
$\frac{v-v_1}{v_2-v}$	$\frac{2}{3}$	$\frac{5}{7}$	1	2	5	∞
N_3	$\frac{2}{3}$	$(\frac{5}{7})$	1 ·	2 ·	(5)	∞

Referred to N_3 this portion of the zone is somewhat incomplete and contains the extra forms $\frac{9}{4}$, $\frac{12}{5}$, $\frac{5}{2}$, $\frac{13}{4}$ and $\frac{9}{2}$.

χ. $(09\bar{9}4)$. This rhombohedron is recorded by Bournon[38] from Derbyshire and Cumberland. It was regarded by Zippe[39] as uncertain. Figure 199 of Bournon suggests that the rhombohedron determined by him as $(09\bar{9}4)$ may possibly be $(05\bar{5}2)$. The zone $[09\bar{9}4\cdot2\bar{1}\bar{1}0]$ contains only one unimportant scalenohedral form. The form must be considered doubtful.

F. $(0\cdot12\cdot\bar{1}\bar{2}\cdot5)$. This rhombohedron was determined by Zippe[40] from a curved face without measurements. It was also found by Sansoni[41] on crystals from Andreasberg, (Combination 189, Fig. 17). Zonal relations suggest a somewhat higher degree of probability for this form than for the preceding.

Ψ. $(05\bar{5}2)$. This rhombohedron was also recorded from Andreasberg by Zippe.[42] In the combination in which it is shown (Fig. 90), $(05\bar{5}2)$ truncate the polar edges of $(12\bar{3}1)$ in the negative sextants, a zonal relation which seems highly rational. Furthermore, the form falls in normal series N_5 and marks the intersection of three well defined zones. The form may be said to be well established.

J. $(0\cdot13\cdot\bar{1}\bar{3}\cdot4)$. This rhombohedron was observed by Rogers[43]

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38 Bournon, C. de., London (1808).
39 Zippe, loc. cit.
40 Zippe, loc. cit.
41 Sansoni, loc. cit.
42 Zippe, loc. cit.
43 Rogers, A. F., S. of M. Quar., **23** (1902).

on crystals from the trap region of New Jersey, and was identified by the fact that its planes truncated the polar edges of $(17\cdot11\cdot\bar{2}\bar{8}\cdot6)$ in the negative sextants. Like the preceding form discussed, it falls in normal series N_5. It also lies in a somewhat well marked zone $[0\cdot13\cdot\bar{1}\bar{3}\cdot4:\bar{2}\bar{1}10]$. The form may be regarded as probable.

Λ. $(09\bar{9}2)$. This rhombohedron was noted by vom Rath[44] on crystals from Andreasberg in combination with $(11\cdot8\cdot\bar{1}\bar{9}\cdot3)$, the polar edges of which it truncates in the negative sextants. It falls in normal series N_5 and may be regarded as probable.

The zone fragment between $(05\bar{5}1)$ and $(0\cdot11\cdot\bar{1}\bar{1}\cdot1)$ contains the following forms:

Form	Ξ. 051	*Q*. 071	Π. 081	*B*. 091	Σ. 0·11·1
Symbol	5	7	8	9	11
$\frac{v-v_1}{v_2-v}$	0	$\frac{1}{2}$	1	2	∞
N_2	0	$\frac{1}{2}$	1	2	∞

Referred to N_2 this section of the zone is complete.

The zone fragment between $(0\cdot11\cdot\bar{1}\bar{1}\cdot1)$ and $(01\bar{1}0)$ contains the following forms:

Form	Σ. 0·11·1	*C*. 0·13·1	Φ. 0·14·1	Ψ. 0·17·1	Ω. 0·20·1	*T*. 0·28·1	*U*. 0·36·1	*m* 010
Symbol	11	13	14	17	20	28	36	∞
$\frac{v-11}{6}$	0	$\frac{1}{3}$	$\frac{1}{2}$	1	$\frac{3}{2}$	$\frac{17}{6}$	$\frac{25}{6}$	
N_3	0	$\frac{1}{3}$	$\frac{1}{2}$ ·	1	$\frac{3}{2}$ ·	$(\frac{17}{6})$ ··	$(\frac{25}{6})$	∞

This section of the zone is incomplete and contains the extra forms 28 and 36.

T. $(0\cdot28\cdot\bar{2}\bar{8}\cdot1)$. This rhombohedron was noted by Thürling[45] on one specimen from Andreasberg. Although the observations of the author cited agree very closely with theory, it is significant that the rhombohedron $(0\cdot29\cdot\bar{2}\bar{9}\cdot1)$, the ρ value of which varies only 4′ from that of $(0\cdot28\cdot\bar{2}\bar{8}\cdot1)$, corresponds to much simpler Miller indices $[(0\cdot29\cdot\bar{2}\bar{9}\cdot1) = (10\cdot10\cdot\bar{1}\bar{9}),\ (0\cdot28\cdot\bar{2}\bar{8}\cdot1) = (29\cdot29\cdot\bar{5}\bar{5})]$ and lies in normal series N_3. The form $(0\cdot28\cdot\bar{2}\bar{8}\cdot1)$ should be regarded as doubtful.

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44 vom Rath, G., Pogg. Ann., **132**, 517 (1867).
45 Thürling, loc. cit.

U. $(0\cdot36\cdot\bar{3}\bar{6}\cdot1)$. This rhombohedron was noted by Johansson [46] on crystals from Norberg, Sweden. In this instance, since the form was observed on crystals of rhombohedral habit, it was impossible to verify the identification of this rhombohedron from zonal relations with scalenohedral forms. The hypothetical rhombohedron $(0\cdot35\cdot\bar{3}\bar{5}\cdot1)$ differs from $(0\cdot36\cdot\bar{3}\bar{6}\cdot1)$ in but $2\frac{1}{2}'$ of ρ value, has much simpler Miller indices $[(0\cdot35\cdot\bar{3}\bar{5}\cdot1) = (12\cdot12\cdot\bar{2}\bar{3})$, $(0\cdot36\cdot\bar{3}\bar{6}\cdot1) = (37\cdot37\cdot\bar{7}\bar{1})]$ and falls in normal series N_4. The rhombohedron $(0\cdot36\cdot\bar{3}\bar{6}\cdot1)$ should be regarded as doubtful.

Hypothetical Rhombohedrons.— None of the forms missing from normal series N_3 as developed above suggest by zonal relations the possibility of hypothetical rhombohedrons between the limits discussed. The two hypothetical forms $(0\cdot29\cdot\bar{2}\bar{9}\cdot1)$ and $(0\cdot35\cdot\bar{3}\bar{5}\cdot1)$ suggested in the above discussion should not be retained as such.

Zone 3 = Z_3 Negative Rhombohedrons

Letter	Form	Knot	N_1	N_2	N_3	N_4	N_5	?	Zone intersections
$\alpha\cdot$	$01\bar{1}5$				N_3				
$\beta\cdot$	$0\cdot7\cdot\bar{7}\cdot20$							?	
$\gamma\cdot$	$02\bar{2}5$			N_2					
$\delta\cdot$	$01\bar{1}2$	×							Z_4, Z_8
$\mathfrak{a}\cdot$	$0\cdot11\cdot\bar{1}\bar{1}\cdot20$							?	
$\epsilon\cdot$	$03\bar{3}5$					N_4			
$\varsigma\cdot$	$02\bar{2}3$			N_2					
$\mathfrak{b}\cdot$	$0\cdot18\cdot\bar{1}\bar{8}\cdot25$							?	
$S\cdot$	$0\cdot11\cdot\bar{1}\bar{1}\cdot14$					N_4			
$\eta\cdot$	$04\bar{4}5$				N_3				
$\mathfrak{v}\cdot$	$0\cdot14\cdot\bar{1}\bar{4}\cdot17$							?	
$\theta\cdot$	$07\bar{7}8$				N_3				
$D\cdot$	$0\cdot19\cdot\bar{1}\bar{9}\cdot20$							?	
$\kappa\cdot$	$01\bar{1}1$	×							Z_9
$\mathfrak{h}\cdot$	$0\cdot17\cdot\bar{1}\bar{7}\cdot16$							?	
$\lambda\cdot$	$08\bar{8}7$						N_5		

[46] Johansson, K., Geol. Fören. Förh. **14**, 49 (1892).

Zone 3 = Z_3 Negative Rhombohedrons (continued).

Letter	Form	Knot	N_1	N_2	N_3	N_4	N_5	?	Zone intersections
μ·	$06\bar{6}5$				N_3				
υ·	$05\bar{5}4$			N_2					Z_{12}
G·	$0\cdot14\cdot\bar{1}4\cdot11$					N_4			
ξ·	$04\bar{4}3$		N_1						
H·	$0\cdot18\cdot\bar{1}8\cdot13$					N_4			
π·	$07\bar{7}5$			N_2					
P·	$0\cdot13\cdot\bar{1}3\cdot9$					N_4			
Y·	$0\cdot19\cdot\bar{1}9\cdot13$							?	
ρ·	$03\bar{3}2$	×							
σ·	$0\cdot11\cdot\bar{1}1\cdot7$				N_3				
f·	$08\bar{8}5$			N_2					
ι·	$0\cdot13\cdot\bar{1}3\cdot8$				N_3				
L·	$05\bar{5}3$		N_1						
M·	$07\bar{7}4$			N_2					
A·	$09\bar{9}5$				N_3				
N·	$0\cdot11\cdot\bar{1}1\cdot6$					N_4			
φ·	$02\bar{2}1$	×							Z_4, Z_5
χ·	$09\bar{9}4$							?	
F·	$0\cdot12\cdot\bar{1}2\cdot5$							?	
Ψ·	$05\bar{5}2$						N_5		
ω·	$0\cdot11\cdot\bar{1}1\cdot4$				N_3				
Γ·	$03\bar{3}1$			N_2					
β·	$0\cdot16\cdot\bar{1}6\cdot5$				N_3				
J·	$0\cdot13\cdot\bar{1}3\cdot4$						N_5		
Δ·	$07\bar{7}2$		N_1						Z_{13}
Θ·	$04\bar{4}1$			N_2					
Λ·	$09\bar{9}2$						N_5		
Ξ·	$05\bar{5}1$	×							Z_{10}, Z_{11}
Q·	$07\bar{7}1$			N_2					
Π·	$08\bar{8}1$		N_1						Z_7
B·	$09\bar{9}1$			N_2					
Σ·	$0\cdot11\cdot\bar{1}1\cdot1$	×							

Zone 3 = Z_3 Negative Rhombohedrons (concluded).									
Letter	From	Knot	N_1	N_2	N_3	N_4	N_5	?	Zone intersections
$C\cdot$	$0\cdot13\cdot\bar{1}\bar{3}\cdot1$				N_3				
$\Phi\cdot$	$0\cdot14\cdot\bar{1}\bar{4}\cdot1$			N_2					
Ψ	$0\cdot17\cdot\bar{1}\bar{7}\cdot1$		N_1						
$\Omega\cdot$	$0\cdot20\cdot\bar{2}\bar{0}\cdot1$				N_3				
$T\cdot$	$0\cdot28\cdot\bar{2}\bar{8}\cdot1$							?	
$U\cdot$	$0\cdot36\cdot\bar{3}\bar{6}\cdot1$							?	
Hypothetical Rhombohedrons									
	$01\bar{1}4$			N_2					
	$01\bar{1}3$		N_1						

In the discussion of the foregoing zones the Bravais symbols have been employed for the obvious reason that they express most clearly the relations of the forms to the zones discussed. In considering the scalenohedral forms, however, the zonal and serial relations are much better emphasized by the Miller symbols, which furthermore are more rational for the more prominent zone intersections. The Miller symbols have consequently been adopted for the subsequent analysis.

ZONE 4 — SCALENOHEDRONS OF THE ZONE $[01\bar{1}2 : 10\bar{1}1] = [110 : 100]$

SYMBOL $\frac{h}{k}$.

In this portion of the principal zone a great number of scalenohedrons have been observed in the comparatively small arc comprised between the limiting poles. Prominent zone intersections occur at $(11\bar{2}2) = (210)$ and $(21\bar{3}4) = (310)$. Splitting the zone at these poles we have for the forms in the first fragment:

Form	δ.	f:	h:	z:	i:	u:	y:	π
	110	760	540	320	11·7·0	850	530	210
Symbol	1	$\frac{7}{6}$	$\frac{5}{4}$	$\frac{3}{2}$	$\frac{11}{7}$	$\frac{8}{5}$	$\frac{5}{3}$	2
$\frac{v-v_1}{v_2-v}$	0	$\frac{1}{6}$	$\frac{1}{3}$	1	$\frac{4}{3}$	$\frac{3}{2}$	2	∞
N_3	0	$(\frac{1}{6})$	$\frac{1}{3}$	1	$(\frac{4}{3})$	$\frac{3}{2}$	2	∞

Referred to N_3 this zone fragment is incomplete and contains the extra forms $\frac{7}{6}$ and $\frac{11}{7}$.

$\mathfrak{k} : (1\cdot6\cdot\bar{7}\cdot13) = (760)$. This scalenohedron was noted by Schaller [47] on crystals from California. It lies in the zone $[0001 : 16\bar{7}0]$ which contains the forms $(16\bar{7}4)$ and $16\bar{7}1)$, but of which the limiting prism has not as yet been recorded. The form falls in normal series N_5 and may be considered fairly probable.

$i : (4\cdot7\cdot\bar{1}\bar{1}\cdot18) = (11\cdot7\cdot0)$. This scalenohedron was recorded by Moesz [48] on crystals from Körösmezö, Hungary. Although the pole of $(4\cdot7\cdot\bar{1}\bar{1}\cdot18)$ does not mark the intersection of any well defined zone, the form falls in normal series N_4 and should be regarded as fairly probable.

Hypothetical Scalenohedrons: The hypothetical form $(13\bar{4}7) = (430)$ reduces to $\frac{1}{2}$ in the above development. The hypothetical scalenohedron $(13\bar{4}7)$ lies in the well defined vertical zone $[0001 : 13\bar{4}0]$ of which the limiting prism is a very well established form. Several other more or less well marked zones intersect at this pole. The form should be retained as hypothetical.

In the zone fragment between $(11\bar{2}3) = (210)$ and $(21\bar{3}4) = (310)$ the following forms have been observed:

Form	π 210	k: 940	x: 730	l: 520	v: 11·4·0	m: 17·6·0	t: 310
Symbol	2	$\frac{9}{4}$	$\frac{7}{3}$	$\frac{5}{2}$	$\frac{11}{4}$	$\frac{17}{6}$	3
$\frac{v - v_1}{v_2 - v}$	0	$\frac{1}{3}$	$\frac{1}{2}$	1	3	5	∞
N_3	0	$\frac{1}{3}$	$\frac{1}{2}$ ·	1	·· 3	(5)	∞

Referred to N_3 this portion of the zone is incomplete and contains the extra form $\frac{17}{6}$.

$m : (11\cdot6\cdot\bar{1}\bar{7}\cdot23) = (17\cdot6\cdot0)$. This scalenohedron was noted by Gonnard [49] on crystals from Couzon, France. The form does not fall at any zone intersection and must be regarded as doubtful.

The zone fragment between $(21\bar{3}4) = (310)$ and $(10\bar{1}1) = (100)$ contains the following forms:—

Form	t: 310	$\mathfrak{h}$: 16·5·0	n: 10·3·0	g: 720	w: 410	f: 920	e: 510	o: 11·2·0
Symbol	3	$\frac{16}{5}$	$\frac{10}{3}$	$\frac{7}{2}$	4	$\frac{9}{2}$	5	$\frac{11}{2}$
$v - 3$	0	$\frac{1}{5}$	$\frac{1}{3}$	$\frac{1}{2}$	1	$\frac{3}{2}$	2	$\frac{5}{2}$
N_3	0	$(\frac{1}{5})$	$\frac{1}{3}$	$\frac{1}{2}$ ·	1	$\frac{3}{2}$	2	$(\frac{5}{2})$

47 Schaller, W. T., Zeit. f. Kryst., **44**, 324 (1908).
48 Moesz, G., Fold. Közlöny., **27**, 495 (1897).
49 Gonnard, F., Bull. Soc. fr. Min., **20** (1897).

Form	q: 610	α: 13·2·0	c: 710	b: 810	a: 910	β: 10·1·0	d: 14·1·0	p· 100
Symbol	6	$\frac{13}{2}$	7	8	9	10	14	∞
$v-3$	3	$\frac{7}{2}$	4	5	6	7	11	∞
N_3	3	$(\frac{7}{2})$	(4)	(5)	(6)	(7)	(11)	∞

This fragment of the zone is somewhat incomplete with respect to N_3 and contains a great many extra forms some of which fall in normal series N_4.

$\mathfrak{h}$: $(11\cdot5\cdot\bar{16}\cdot21) = (16\cdot5\cdot0)$. This scalenohedron was observed by Schaller [50] on crystals from Terlingua, Texas. The form was determined from extremely small planes, giving weak signals. The vertical zone $[0001 : 11\cdot5\cdot\bar{16}\cdot21]$ also contains the form $(11\cdot5\cdot\bar{16}\cdot6)$ which marks several zone intersections. The form which falls in normal series N_5 seems fairly probable.

o : $(9\cdot2\cdot\bar{11}\cdot13) = (11\cdot2\cdot0)$. This scalenohedron was noted by Melczer [51] on crystals from Budapest. The pole $(9\cdot2\cdot\bar{11}\cdot13)$ does not fall in any zone other than the one under discussion and although the term $\frac{5}{2}$ is referable to normal series N_4 the form should be regarded as somewhat doubtful.

α: $(11\cdot2\cdot\bar{13}\cdot15) = (13\cdot2\cdot0)$. This scalenohedron was noted by Sansoni [52] on three crystals from Andreasberg. The measured angles as determined by him agree well with theory although the pole lies very close to $(61\bar{7}8)$, a form which agrees better in zonal relations. The scalenohedron $(11\cdot2\cdot\bar{13}\cdot15)$, however, is referable to normal series N_5 and should be regarded as somewhat probable.

c: $(61\bar{7}8) = (710)$. This scalenohedron was first noted by Hausmann [53] on crystals from Andreasberg. The form was later observed by Hessenberg [54] and is regarded by Irby as well established. The zone $[61\bar{7}8 : 01\bar{1}0]$ is, moreover very well marked and the form falls in normal series N_4. It should be regarded as well established.

b: $(71\bar{8}9) = (810)$. This scalenohedron was first recorded by Sella [55] on crystals from Sardinia. It was subsequently noted by Hessenberg from Andreasberg and by vom Rath from Lake Superior. It falls in normal series N_5 and although not as rational

50 Schaller, loc. cit.
51 Melczer, loc. cit.
52 Sansoni, F., Acad. d. Linc., **19**, Pl. 3, Fig. 20 (1884).
53 Hausmann, J. F. L., Handbuch der Mineralogie (1847).
54 Hessenberg, loc. cit.
55 Sella, Q., Mem. Ac. Turin., 2, **17**, (1856).

from the point of view of zonal relations as the previous form should be regarded as well established.

a: $(8\cdot1\cdot\bar{9}\cdot10) = (910)$. This scalenohedron was first recorded by Zippe [56] on crystals from Andreasberg and was subsequently noted by vom Rath [57] from Lake Superior, and by Sansoni [58] from Andreasberg. The zone $[8\cdot1\cdot\bar{9}\cdot10 : 01\bar{1}0]$ is well marked and the form is probable.

β: $(9\cdot1\cdot1\bar{0}\cdot11) = (10\cdot1\cdot0)$. This scalenohedron was observed by Sansoni [59] on crystals from Andreasberg. The form occurs on combination 249, Figure 19, in combination with $(01\bar{1}2)$ and $(8\cdot1\cdot\bar{9}\cdot10)$. It marks the intersection of two minor zones containing several prominent forms. The form may be ranked as well established.

d: $(13\cdot1\cdot\bar{1}\bar{4}\cdot15) = (14\cdot1\cdot0)$. This scalenohedron was observed by vom Rath [60] on crystals from the trap of the Nahe basin. The form was determined by approximate measurements on corroded faces. Furthermore it lies very close to $(10\bar{1}1)$ and falls in a high normal series. The form should be classed as doubtful.

ZONE 4. SCALENOHEDRONS OF THE ZONE $[10\bar{1}1 : 11\bar{2}0] = [100 : 10\bar{1}]$

SYMBOL $\frac{l}{h}$.

In this portion of the principal zone the prominent zone intersections occur at the poles of the common scalenohedrons $H : (31\bar{4}2) = (30\bar{1})$, $K : (21\bar{3}1) = (20\bar{1})$, $P : (32\bar{5}1) = (30\bar{2})$ and $T : (32\bar{7}1) = (40\bar{3})$. Splitting the zone at these points we have for the forms in the fragment between (100) and $30\bar{1}$):

Form	$p\cdot$ 100	A: $11\cdot0\cdot\bar{1}$	B: $17\cdot0\cdot\bar{2}$	C: $70\bar{1}$	γ: $19\cdot0\cdot\bar{3}$	D: $60\bar{1}$	E: $50\bar{1}$	I: $13\cdot0\cdot\bar{3}$
Symbol	0	$\frac{1}{11}$	$\frac{2}{17}$	$\frac{1}{7}$	$\frac{3}{19}$	$\frac{1}{6}$	$\frac{1}{5}$	$\frac{3}{13}$
$\frac{v - v_1}{v_2 - v}$	0	$\frac{3}{8}$	$\frac{6}{11}$	$\frac{3}{4}$	$\frac{9}{10}$	1	$\frac{3}{2}$	$\frac{9}{4}$
$\frac{2v^1}{3}$	0	$\frac{1}{4}$	$\frac{4}{11}$	$\frac{1}{2}$	$\frac{3}{5}$	$\frac{2}{3}$	1	$\frac{3}{2}$
N_4	0	$\frac{1}{4}$ ·	$(\frac{4}{11})$ ·	$\frac{1}{2}$	$\frac{3}{5}$	$\frac{2}{3}$ ·	1 ·	$\frac{3}{2}$

56 Zippe, loc. cit.
57 vom Rath, G., Pogg. Ann., **132**, 137.
58 Sansoni, loc. cit.
59 Sansoni, loc. cit.
60 vom Rath, G., Pogg. Ann., **135**, 572.

Form	Z: $21\cdot0\cdot\bar{5}$	F: $40\bar{1}$	δ: $19\cdot0\cdot\bar{5}$	μ: $11\cdot0\cdot\bar{3}$	G: $70\bar{2}$	λ: $17\cdot0\cdot\bar{5}$	H: $30\bar{1}$
Symbol	$\frac{5}{21}$	$\frac{1}{4}$	$\frac{5}{19}$	$\frac{3}{11}$	$\frac{2}{7}$	$\frac{5}{17}$	$\frac{1}{3}$
$\frac{v-v_1}{v_2-v}$	$\frac{5}{2}$	3	$\frac{15}{4}$	$\frac{9}{2}$	6	$\frac{15}{2}$	∞
$\frac{2v^1}{3}$	$\frac{5}{3}$	2	$\frac{5}{2}$	3	4	5	∞
N_4	$\frac{5}{3}$	2	$\frac{5}{2}$	3	4	(5)	∞

Referred to N_4 this fragment of the zone is nearly complete and contains the extra forms $\frac{2}{17}$ and $\frac{5}{17}$.

B: $(17\cdot2\cdot\bar{1}\bar{9}\cdot15) = (17\cdot0\cdot\bar{2})$. This scalenohedron according to Irby has been observed a number of times.[61] Although not a prominent zone intersection, the form seems to be fairly probable.

λ: $(17\cdot5\cdot\bar{2}\bar{2}\cdot8) = (15\cdot0\cdot\bar{7})$. This scalenohedron was noted by Rogers [62] as occurring on calcite crystals from Great Notch, N. J. Although somewhat striated parallel to the zone the form is said to have given good reflections. It should be classed as fairly probable.

In the zone fragment between H: and K: the following forms have been recorded:

Form	H: $30\bar{1}$	J: $50\bar{2}$	ξ: $70\bar{3}$	Π: $11\cdot0\cdot\bar{5}$	Ψ: $15\cdot0\cdot\bar{7}$	K: $20\bar{1}$
Symbol	$\frac{1}{3}$	$\frac{2}{5}$	$\frac{3}{7}$	$\frac{5}{11}$	$\frac{7}{15}$	$\frac{1}{2}$
$\frac{v-v_1}{v_2-v}$	0	$\frac{2}{3}$	$\frac{4}{3}$	$\frac{8}{3}$	4	∞
$\frac{3v^1}{4}$	0	$\frac{1}{2}$	1	2	3	∞
N_2	0	$\frac{1}{2}$	1	2	(3)	∞

Referred to N_2 this fragment of the zone is complete and contains the extra form $\frac{7}{15}$.

Ψ: $(15\cdot7\cdot\bar{2}\bar{2}\cdot8) = (15\cdot0\cdot\bar{7})$. This scalenohedron was observed by Schnorr [63] on crystals from Neumark, Prussia. Although the pole

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61 von Zepharovich, V. R., on calcite from Bleiburg, Lotos (1878).
Hessenberg, F., on calcite from Bleiburg, Min. Not., **8**.
Schnorr, on calcite from Zwickau (1874).
vom Rath, G., on calcite from Ahrenthal, Pogg. Ann., **155**.

62 Rogers A. F., S. of M. Quar., **23**, 336 (1902).

63 Schnorr, Wissensch. Beil. z. Programme des Realgym. zu Zwickau, **16** (1896).

of $(15\cdot7\cdot\overline{22}\cdot8)$ does not fall at any important zone intersection, the form occurs in normal series N_3 in the above development and may be considered fairly probable.

In the zone fragment between K: and P: the following scalenohedrons have been observed:

Form	K: $20\bar{1}$	σ: $41\cdot0\cdot\bar{2}1$	τ: $25\cdot0\cdot\bar{1}3$	L: $17\cdot0\cdot\bar{9}$	ϵ: $90\bar{5}$	M: $70\bar{4}$	φ: $19\cdot0\cdot\bar{1}1$
Symbol	$\frac{1}{2}$	$\frac{21}{41}$	$\frac{13}{25}$	$\frac{9}{17}$	$\frac{5}{9}$	$\frac{4}{7}$	$\frac{11}{19}$
$\frac{v-v_1}{v_2-v}$	0	$\frac{3}{38}$	$\frac{3}{22}$	$\frac{3}{14}$	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{9}{10}$
$\frac{2r^1}{3}$	0	$\frac{1}{19}$	$\frac{1}{11}$	$\frac{1}{7}$	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{3}{5}$
N_3	0	$(\frac{1}{19})$	$(\frac{1}{11})$	$(\frac{1}{7})$	$\frac{1}{3}$	$\frac{1}{2}$	$(\frac{3}{5})$

Form	χ: $29\cdot0\cdot\bar{1}7$	N: $50\bar{3}$	$13\cdot0\cdot\bar{8}$	o: $80\bar{5}$	p: $17\cdot0\cdot\bar{1}1$	P: $30\bar{2}$
Symbol	$\frac{17}{29}$	$\frac{3}{5}$	$\frac{8}{13}$	$\frac{5}{8}$	$\frac{11}{17}$	$\frac{2}{3}$
$\frac{v-v_1}{v_2-v}$	$\frac{15}{14}$	$\frac{3}{2}$	$\frac{9}{4}$	3	$\frac{15}{2}$	∞
$\frac{2r^1}{3}$	$\frac{5}{7}$	1	$\frac{3}{2}$	2	5	∞
N_3	$(\frac{5}{7})$	1	$\frac{3}{2}$	2	(5)	∞

Referred to N_3 this zone fragment is somewhat incomplete and contains the extra forms $\frac{21}{41}$, $\frac{13}{25}$, $\frac{9}{17}$, $\frac{11}{19}$, $\frac{17}{29}$, and $\frac{11}{17}$, three of which are obviously close to the pole of the common form $(21\bar{3}1) = (20\bar{1})$.

σ: $(41\cdot21\cdot\bar{6}\bar{2}\cdot20) = (41\cdot0\cdot\bar{2}1)$
τ: $(25\cdot13\cdot\bar{3}\bar{8}\cdot12) = (25\cdot0\cdot\bar{1}3)$ } These two scalenohedrons were reported by Sansoni [64] from Schapbachthal, Baden. They were found on one crystal and are evidently vicinal to K: $(21\bar{3}1)$. Both forms, although included in the lists of Rogers [65], Bumuller [66] and Whitlock [67], should be classed as doubtful.

L: $(17\cdot9\cdot\bar{2}6\cdot8) = (17\cdot0\cdot\bar{9})$. This scalenohedron was first noted by Zippe [68] on crystals from Hoffnungsbergbrau, near Lissnia, on

64 Sansoni, F., Giorn. d. Min., **1** (2), 299 (1900).
65 Rogers, A. F., S. of M. Quar., **22**, 429 (1901).
66 Bumuller, C. N., Jahrb. f. Min. B. B., **28**, 233.
67 Whitlock, H. P., N. Y. State Mus. Mem., **13**, 42 (1910).
68 Zippe, F. X. M., loc. cit.

which the scalenohedron K: is not present, the only other scalenohedron of the principal zone being $V: (6\cdot5\cdot\bar{1}1\cdot1) = (60\bar{5})$. Sansoni [69] has noted the form on a crystal from Schapbachthal where he describes it as vicinal to K:. The form is somewhat doubtful but more probable than the two preceding.

$\varphi: (19\cdot11\cdot\bar{3}\bar{0}\cdot8) = (19\cdot0\cdot\bar{1}\bar{1})$. This scalenohedron was observed by Sansoni [70] on crystals from Monticatini, Italy. Although this form falls in Normal series N_4 it is noteworthy that the hypothetical scalenohedron $(12\cdot7\cdot\bar{1}\bar{9}\cdot5) = (12\cdot0\cdot\bar{7})$ which falls in normal series N_3 in the above development presents better zonal relation than $(19\cdot11\cdot\bar{3}\bar{0}\cdot8)$. The form is fairly probable.

$\chi: (29\cdot17\cdot\bar{4}\bar{6}\cdot12) = (29\cdot0\cdot\bar{1}7)$. This scalenohedron was first noted by Schnorr [71] on crystals from Neumark. As noted above the hypothetical scalenohedron $(12\cdot7\cdot\bar{1}\bar{9}\cdot5) = (12\cdot0\cdot\bar{7})$ which reduces to $\frac{2}{3}$ in normal series N_3 lies between the forms $\varphi: (19\cdot11\cdot\bar{3}0\cdot8) = (19\cdot0\cdot\bar{1}1)$ and $\chi: (29\cdot17\cdot\bar{4}\bar{6}\cdot12) = (29\cdot0\cdot\bar{1}\bar{7})$ in the zone, possesses much more rational Miller indices and lies close enough to χ: to be within the limit of error of an ordinary observation. It is possible that χ: should be referred to the simpler indices.

$p: (17\cdot11\cdot\bar{2}\bar{8}\cdot6) = (17\cdot0\cdot\bar{1}\bar{1})$. This scalenohedron was found by Palache [72] on two crystals from the Lake Superior region of Michigan. The form falls in normal series N_5 and also marks the intersection of at least two well defined secondary zones. The form is probable.

Hypothetical Scalenohedron. The hypothetical scalenohedron $(12\cdot7\cdot\bar{1}\bar{9}\cdot5)$ referred to above should be retained as a hypothetical form.

The following forms have been recorded between the poles P: $(32\bar{5}1) = (30\bar{2})$ and $T: (43\bar{7}1) = (40\bar{3})$:

Form	P: $30\bar{2}$	Q: $19\cdot0\cdot13$	$13\cdot0\cdot\bar{9}$	R: $10\cdot0\cdot\bar{7}$	s: $70\bar{5}$	s: $11\cdot0\cdot\bar{8}$	η $23\cdot0\cdot\bar{1}\bar{7}$	T: $40\bar{3}$
Symbol	$\frac{2}{3}$	$\frac{13}{19}$	$\frac{9}{13}$	$\frac{7}{10}$	$\frac{5}{7}$	$\frac{8}{11}$	$\frac{17}{23}$	$\frac{3}{4}$
$\frac{v-v_1}{v_2-v}$	0	$\frac{4}{15}$	$\frac{4}{9}$	$\frac{2}{3}$	$\frac{4}{3}$	$\frac{8}{3}$	$\frac{20}{3}$	∞
$\frac{3v^1}{4}$	0	$\frac{1}{5}$	$\frac{1}{3}$	$\frac{1}{2}$	1	2	5	∞
N_3	0	$(\frac{1}{5})$	$\frac{1}{3}$	$\frac{1}{2}$	1	2	(5)	∞

69 Sansoni, F., loc. cit.
70 Sansoni, F., Atti Acc. Torino, **23** (1888).
71 Schnorr, loc. cit.
72 Palache, C., Mich. Geol. Surv., **6**, 16 (1897).

Referred to N_3 this fragment of the zone is somewhat incomplete and contains the extra forms $\frac{13}{19}$ and $\frac{17}{23}$ both of which fall in normal series N_5.

Q: $(19\cdot13\cdot\overline{32}\cdot6) = (19\cdot0\cdot\overline{13})$. This scalenohedron was noted by Hessenberg [73] on crystals from Andreasberg. Irby [74] in commenting on this form in his list, states that the only determination of it is not perfectly satisfactory. Sansoni [75] includes it in combination 242 from Andreasberg which he ascribes to Hessenberg without comment. The form must be considered as rather improbable.

η : $(23\cdot17\cdot\overline{40}\cdot6) = (23\cdot0\cdot\overline{17})$. This scalenohedron was described by Sansoni [76] on three crystals from Andreasberg. Although the pole does not lie in any well defined secondary zone, the angular values as determined by Sansoni agree so well with theory as to place the form beyond question.

The following relatively steep scalenohedral forms have been recorded in the zone fragment between T : $(43\overline{7}1) = (40\overline{3})$ and a $(11\overline{2}0) = (10\overline{1})$.

Form	T: $40\overline{3}$	Θ: $90\overline{7}$	U: $50\overline{4}$	$11\cdot0\cdot\overline{9}$	V: $60\overline{5}$	W: $13\cdot0\cdot\overline{11}$	X: $70\overline{6}$
Symbol	$\frac{3}{4}$	$\frac{7}{9}$	$\frac{4}{5}$	$\frac{9}{11}$	$\frac{5}{6}$	$\frac{11}{13}$	$\frac{6}{7}$
$\frac{v-v_1}{v_2-v}$	0	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$
$2v^1$	0	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$\frac{5}{4}$	$\frac{3}{2}$
N_4	0	$\frac{1}{4}$ ..	$\frac{1}{2}$ ..	$\frac{3}{4}$	1	$(\frac{5}{4})$.	$\frac{3}{2}$.

Form	ω: $15\cdot0\cdot\overline{13}$	ι: $17\cdot0\cdot\overline{15}$	Y: $90\overline{8}$	v: $10\cdot0\cdot\overline{9}$	κ: $21\cdot0\cdot\overline{19}$	a $10\overline{1}$
Symbol	$\frac{13}{15}$	$\frac{15}{17}$	$\frac{8}{9}$	$\frac{9}{10}$	$\frac{19}{21}$	1
$\frac{v-v_1}{v_2-v}$	$\frac{7}{8}$	$\frac{9}{8}$	$\frac{5}{4}$	$\frac{3}{2}$	$\frac{13}{8}$	∞
$2v^1$	$\frac{7}{4}$	$\frac{9}{4}$	$\frac{5}{2}$	3	$\frac{13}{4}$	∞
N_4	$(\frac{7}{4})$.	$(\frac{9}{4})$	$\frac{5}{2}$	3	$(\frac{13}{4})$	∞

This zone fragment is quite incomplete and contains the extra forms $\frac{11}{13}$, $\frac{13}{15}$, $\frac{15}{17}$ and $\frac{19}{21}$.

W: $(13\cdot11\cdot\overline{24}\cdot2) = (13\cdot0\cdot\overline{11})$. This scalenohedron has been as-

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73 Hessenberg, F., Min. Not., **4**, Frankfort (1875).
74 Irby, loc. cit.
75 Sansoni, F., R. Accad. d. Linc. Mem., **19** (1884).
76 Sansoni, F., R. Accad. d. Linc. Mem., **19** (1884).

signed to crystals from Andreasberg by Naumann [77] and Hausmann.[78] Irby [79] in commenting on this form throws some doubt on the correctness of the determinations and points out the difficulties in the way of distinguishing it from $(6\cdot5\cdot\overline{11}\cdot1)$ and $(7\cdot6\cdot\overline{13}\cdot1)$ both well established poles on either side of it. Sansoni [80] ascribes the form to Hausmann without comment. The form should be classed as doubtful.

ω: $(15\cdot13\cdot\overline{28}\cdot2) = (15\cdot0\cdot\overline{13})$. This scalenohedron was observed by Stöber [81] on crystals from Framont. On the combination figured it takes the place of the much commoner and more rational form U: $(54\overline{9}1) = (50\overline{4})$ shown in the three preceding figures (Figs. 9, 10 and 11).

It is possible that the form in question should be referred to $(7\cdot6\cdot\overline{13}\cdot1)$, a well established scalenohedron which lies $24\frac{1}{2}'$ from $(15\cdot13\cdot\overline{28}\cdot2)$ or to the hypothetical indices $(8\cdot7\cdot\overline{15}\cdot1)$ which lies even closer in zone.

ι: $(17\cdot15\cdot\overline{32}\cdot2) : (17\cdot0\cdot\overline{15})$. This scalenohedron was observed by Sansoni [82] on crystals from Andreasberg. In spite of the close agreement between measured and calculated angles recorded by Sansoni, it seems doubtful that a scalenohedron should fall in this position in the harmonic series.

κ: $(21\cdot9\cdot\overline{40}\cdot2) = (21\cdot0\cdot\overline{19})$. This scalenohedron was observed by Sansoni [83] on crystals from Arendal, Norway. The number of scalenohedrons of the principal zone present on the combination described by Sansoni suggests that the form under consideration may possibly be vicinal. It should be regarded as rather doubtful.

Hypothetical Scalenohedrons. Normal series N_4 suggests the possibility of a hypothetical scalenohedron which would reduce to 2 in the series. Such a scalenohedron would have the indices $(8\cdot7\cdot\overline{15}\cdot1) = (80\overline{7})$ and would fall between $(15\cdot13\cdot\overline{28}\cdot2)$ and $(17\cdot15\cdot\overline{32}\cdot2)$. In the opinion of the writer the angular difference between the hypothetical form and the two above mentioned lies within the limit of fairly good observation. The form should be retained as hypothetical.

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77 Naumann, C. T., Pogg. Ann., **14**, 235 (1828).
78 Hausmann, J. F. L., Handbuch der Mineralogie, **2** (1847).
79 Irby, loc. cit.
80 Sansoni, loc. cit.
81 Stöber, F., Abh. geol. Karte, Els-Lothr., **5**, Fig. 12 (1892).
82 Sansoni, loc. cit.
83 Sansoni, F., Giorn. d. Min., **1**, 2, p. 129 (1890).

Zone 4 = Z_4 Scalenohedrons of the zone $[01\bar{1}2: 10\bar{1}1: 11\bar{2}0]$

Letter	Bravais	Miller	Knot	N_1	N_2	N_3	N_4	N_5	?	Zone intersections
f:	$1\cdot6\cdot\bar{7}\cdot13$	760						N_5		
h:	$14\bar{5}9$	540				N_3				
z:	$12\bar{3}5$	320		N_1						
i:	$4\cdot7\cdot\bar{11}\cdot18$	11·7·0					N_4			
u:	$3\cdot5\cdot\bar{8}\cdot13$	850				N_3				
y:	$23\bar{5}8$	530			N_2					
k:	$5\cdot4\cdot\bar{9}\cdot13$	940				N_3				
x:	$4\cdot3\cdot\bar{7}\cdot10$	730			N_2					
l:	$32\bar{5}7$	520		N_1						
r:	$7\cdot4\cdot\bar{11}\cdot15$	11·4·0				N_3				
m:	$11\cdot6\cdot\bar{17}\cdot23$	17·6·0						N_5		
t:	$21\bar{3}4$	310	×							
$\mathfrak{h}$:	$11\cdot5\cdot\bar{16}\cdot21$	16·5·0						N_5		
n:	$7\cdot3\cdot\bar{10}\cdot13$	10·3·0				N_3				
g:	$52\bar{7}9$	720			N_2					
w:	$31\bar{4}5$	410		N_1						
f:	$7\cdot2\cdot\bar{9}\cdot11$	920				N_3				
e:	$41\bar{5}6$	510			**N_2**					
o:	$9\cdot2\cdot\bar{11}\cdot13$	11·2·0					**N_4**			
q:	$51\bar{6}7$	610				N_3				
α:	$11\cdot2\cdot\bar{13}\cdot15$	13·2·0						N_5		
c:	$61\bar{7}8$	710					N_4			
b:	$71\bar{8}9$	810						N_5		
a:	$8\cdot1\cdot\bar{9}\cdot10$	910							?	
β:	$9\cdot1\cdot\bar{10}\cdot11$	10·1·0							?	
d:	$13\cdot1\cdot\bar{14}\cdot15$	14·1·0							?	
A:	$11\cdot1\cdot\bar{12}\cdot10$	$11\cdot0\cdot\bar{1}$					N_4			
B:	$17\cdot2\cdot\bar{19}\cdot15$	$17\cdot0\cdot\bar{2}$							?	
C:	$71\bar{8}6$	$70\bar{1}$			N_2					
γ:	$19\cdot3\cdot\bar{22}\cdot16$	$19\cdot0\cdot\bar{3}$					N_4			
D:	$61\bar{7}5$	$60\bar{1}$				N_3				
E:	$51\bar{6}4$	$50\bar{1}$		N_1						

Zone 4 = Z_4 Scalenohedrons of the zone $[01\bar{1}2 : 10\bar{1}1 : 11\bar{2}0]$ (continued)

Letter	Bravais	Miller	Knot	N_1	N_2	N_3	N_4	N_5	?	Zone intersections
I:	$13\cdot3\cdot\bar{1}6\cdot10$	$13\cdot0\cdot\bar{3}$				N_3				
Z:	$21\cdot5\cdot\bar{2}6\cdot16$	$21\cdot0\cdot\bar{5}$					N_4			
F:	$41\bar{5}3$	$40\bar{1}$			N_2					
δ:	$19\cdot5\cdot\bar{2}4\cdot14$	$19\cdot0\cdot\bar{5}$					N_4			
μ:	$11\cdot3\cdot\bar{1}4\cdot8$	$11\cdot0\cdot\bar{3}$				N_3				
G:	$72\bar{9}5$	$70\bar{2}$					N_4			
λ:	$17\cdot5\cdot\bar{2}2\cdot12$	$17\cdot0\cdot\bar{5}$						N_5		
H:	$31\bar{4}2$	$30\bar{1}$	×							Z_{12}
J:	$52\bar{7}3$	$50\bar{2}$			N_2					
ξ:	$7\cdot3\cdot\bar{1}0\cdot4$	$70\bar{3}$		N_1						
π:	$11\cdot5\cdot\bar{1}6\cdot6$	$11\cdot0\cdot\bar{5}$			N_2					
Ψ:	$15\cdot7\cdot\bar{2}2\cdot8$	$15\cdot0\cdot\bar{7}$				N_3				
K:	$21\bar{3}1$	$20\bar{1}$	×							Z_6, Z_{11}
σ:	$41\cdot21\cdot\bar{6}2\cdot20$	$41\cdot0\cdot\bar{2}1$							?	
τ:	$25\cdot13\cdot\bar{3}8\cdot12$	$25\cdot0\cdot\bar{1}3$							?	
L:	$17\cdot9\cdot\bar{2}6\cdot8$	$17\cdot0\cdot\bar{9}$							?	
ϵ:	$9\cdot5\cdot\bar{1}4\cdot4$	$90\bar{5}$				N_3				
M:	$7\cdot4\cdot\bar{1}1\cdot3$	$70\bar{4}$			N_2					
ω:	$19\cdot11\cdot\bar{3}0\cdot8$	$19\cdot0\cdot\bar{1}1$					N_4			
χ:	$29\cdot17\cdot\bar{4}6\cdot12$	$29\cdot0\cdot\bar{1}7$						N_5		
N:	$53\bar{8}2$	$50\bar{3}$		N_1						
	$13\cdot8\cdot\bar{2}1\cdot5$	$13\cdot0\cdot\bar{8}$				N_3				
o:	$8\cdot5\cdot\bar{1}3\cdot3$	$80\bar{5}$			N_2					
p:	$17\cdot11\cdot\bar{2}8\cdot6$	$17\cdot0\cdot\bar{1}1$						N_5		
P:	$32\bar{5}1$	$30\bar{2}$	×							Z_7, Z_{13}
Q:	$19\cdot13\cdot\bar{3}2\cdot6$	$19\cdot0\cdot\bar{1}3$						N_5		
	$13\cdot9\cdot\bar{2}2\cdot4$	$13\cdot0\cdot\bar{9}$				N_3				
R:	$10\cdot7\cdot\bar{1}7\cdot3$	$10\cdot0\cdot\bar{7}$			N_2					
s:	$7\cdot5\cdot\bar{1}2\cdot2$	$70\bar{5}$		N_1						
s:	$11\cdot8\cdot\bar{1}9\cdot3$	$11\cdot0\cdot\bar{8}$			N_2					
η:	$23\cdot17\cdot\bar{4}0\cdot6$	$23\cdot0\cdot\bar{1}7$						N_5		
T:	$43\bar{7}1$	$40\bar{3}$	×							Z_{10}

Zone 4 = Z_4 Scalenohedrons of the zone [$01\bar{1}2$: $10\bar{1}1$: $11\bar{2}0$] (concluded)										
Letter	Bravais	Miller	Knot	N_1	N_2	N_3	N_4	N_5	?	Zone intersections
θ:	$9\cdot7\cdot\bar{1}6\cdot2$	$90\bar{7}$					N_4			
U:	$54\bar{9}1$	$50\bar{4}$			N_2					
	$11\cdot9\cdot\bar{2}0\cdot2$	$11\cdot0\cdot\bar{9}$					N_4			
V:	$6\cdot5\cdot\bar{1}\bar{1}\cdot1$	$60\bar{5}$		N_1						
W:	$13\cdot11\cdot\bar{2}\bar{4}\cdot2$	$13\cdot0\cdot\bar{1}\bar{1}$						N_5		
X:	$7\cdot6\cdot\bar{1}\bar{3}\cdot1$	$70\bar{6}$				N_3				
ω:	$15\cdot13\cdot\bar{2}\bar{8}\cdot2$	$15\cdot0\cdot\bar{1}\bar{3}$						N_5		
ι:	$17\cdot15\cdot\bar{3}\bar{2}\cdot2$	$17\cdot0\cdot\bar{1}\bar{5}$							?	
Y:	$9\cdot8\cdot\bar{1}\bar{7}\cdot1$	$90\bar{8}$					N_4			
υ:	$10\cdot9\cdot\bar{1}\bar{9}\cdot1$	$10\cdot0\cdot\bar{9}$				N_3				
κ:	$21\cdot19\cdot40\cdot2$	$21\cdot0\cdot\bar{1}\bar{9}$							?	
Hypothetical Scalenohedrons										
	$13\bar{4}7$	430			N_2					
	$12\cdot7\cdot\bar{1}\bar{9}\cdot5$	$12\cdot0\cdot7$				N_3				
	$8\cdot7\cdot\bar{1}\bar{5}\cdot1$	$80\bar{7}$			N_2					

ZONE 5 — SCALENOHEDRONS OF THE ZONE [$10\bar{1}1 : 02\bar{2}1$] = [$100 : 11\bar{1}$]

$$\text{SYMBOL} = \frac{k}{h}.$$

Considering this portion of the zone [$10\bar{1}1 : 02\bar{2}1 : 11\bar{2}0$] the major zone intersection suggests the pole ($12\bar{3}2$) = ($21\bar{1}$) as a knot. Splitting the zone at this point and developing the first half, we have for the forms recorded between ($10\bar{1}1$) = (100) and ($12\bar{3}2$) = $21\bar{1}$):

Form	$\left\{\begin{matrix} p. \\ 100 \end{matrix}\right.$	υ: $61\bar{1}$	α: $51\bar{1}$	$\mathfrak{b}$: $41\bar{1}$	λ $31\bar{1}$	$\mathfrak{c}$: $52\bar{2}$	$\mathfrak{d}$: $73\bar{3}$	$\mathfrak{e}$: $21\bar{1}$
Symbol	0	$\frac{1}{6}$	$\frac{1}{5}$	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{2}{5}$	$\frac{3}{7}$	$\frac{1}{2}$
$\frac{v}{v_2 - v}$	0	$\frac{1}{2}$	$\frac{2}{3}$	1	2	4	6	∞
$\frac{v^1}{2}$	0	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{1}{2}$	1	2	3	∞
N_3	0	$(\frac{1}{4})$	$\frac{1}{3}$	$\frac{1}{2}$ ·	1 ·	2	3	∞

Referred to N_3 this zone fragment is somewhat incomplete and contains the extra form $\frac{1}{6}$.

$\mathfrak{v}\,(52\bar{7}6) = (61\bar{1})$. This scalenohedron was recorded by Moesz [84] on crystals from Körösmezö, Hungary. The form which is referable to normal series N_4 falls at the intersection of a number of well marked secondary zones. It should be ranked as probable.

The following scalenohedrons have been recorded in the zone fragment between the limits $(12\bar{3}2) = (21\bar{1})$ and $(02\bar{2}1) = (11\bar{1})$:

Form	e $21\bar{1}$	f $95\bar{5}$	ȝ $53\bar{3}$	g $32\bar{2}$	h $75\bar{5}$	i $43\bar{3}$	f $54\bar{4}$	u $65\bar{5}$	m $98\bar{8}$	φ $11\bar{1}$
Symbol	$\frac{1}{2}$	$\frac{5}{9}$	$\frac{3}{5}$	$\frac{2}{3}$	$\frac{5}{7}$	$\frac{3}{4}$	$\frac{4}{5}$	$\frac{5}{6}$	$\frac{8}{9}$	1
$\frac{v - v_1}{v_2 - v}$	0	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$\frac{3}{2}$	2	$\frac{7}{2}$	∞
$2v^1$	0	$\frac{1}{4}$	$\frac{1}{2}$	1	$\frac{3}{2}$	2	3	4	7	∞
N_4	0	$\frac{1}{4}$ ..	$\frac{1}{2}$ ...	1 .	$\frac{3}{2}$.	2 .	3	4	(7)	∞

Referred to N_4 this zone fragment is very incomplete and contains the extra form $\frac{8}{9}$.

$\mathfrak{m}\,(1\cdot16\cdot\bar{1}\bar{7}\cdot9) = (98\bar{8})$. This form, as pointed out by Irby, was substituted by Zippe [85] for $(14\bar{5}3) = (32\bar{2})$ in Lévy's [86] figure of a Derbyshire occurrence. Irby favors discarding the figure of Lévy on the ground that the zonal relations shown in the drawing do not conform to the indices assigned. The form must be regarded as doubtful.

Zone 5 — Scalenohedrons of the Zone $[02\bar{2}1 : 11\bar{2}0] = [11\bar{1} : 10\bar{1}]$

Symbol $\frac{h}{k}$.

This portion of the zone $[10\bar{1}1 : 02\bar{2}1 : 11\bar{2}0]$ can be developed as a whole without splitting:

Form	φ. $11\bar{1}$	ŋ $43\bar{4}$	n $32\bar{3}$	a $53\bar{5}$	p $21\bar{2}$	q $31\bar{3}$	t $11\cdot3\cdot\bar{1}\bar{1}$	r $41\bar{4}$	ſ $51\bar{5}$	a $10\bar{1}$
Symbol	1	$\frac{4}{3}$	$\frac{3}{2}$	$\frac{5}{3}$	2	3	$\frac{11}{3}$	4	5	∞
$v - 1$	0	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{2}{3}$	1	2	$\frac{8}{3}$	3	4	∞
N_3	0	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{2}{3}$	1 .	2	(8/3)	3	(4)	∞

Referred to N_3 this zone fragment is nearly complete and contains the extra forms $\frac{11}{3}$ and 5.

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84 Moesz, G., Föld. Közlöny, **27**, 495 (1897).

85 Zippe, loc. cit., Fig. 15.

86 Lévy, A., Description d'une collection des mineraux formée par M. Heuland, London, Fig. 122 (1837).

t: $(8\cdot14\cdot\bar{2}\bar{2}\cdot3) = (11\cdot3\cdot\bar{1}\bar{1})$. This scalenohedron was observed by Whitlock [87] on crystals from Lyon Mountain, N. Y. The poles of the form lie at the intersection of several well marked zones. In the combination cited, well developed planes of the form bevel the edges $8\cdot8\cdot\bar{1}\bar{6}\cdot3 : 01\bar{1}0$. The form falls in normal series N_5 and may be regarded as fairly probable.

Zone 5 = Z_5 Scalenohedron of the zone $[10\bar{1}1 : 02\bar{2}1 : 11\bar{2}0]$

Letter	Bravais	Miller	Knot	N_1	N_2	N_3	N_4	N_5	?	Zone intersections
v:	$52\bar{7}6$	$61\bar{1}$					N_4			
a:	$42\bar{6}5$	$51\bar{1}$				N_3				
b:	$32\bar{5}4$	$41\bar{1}$			N_2					
c:	$34\bar{7}5$	$52\bar{2}$			N_2					
d:	$4\cdot6\cdot\bar{1}0\cdot7$	$73\bar{3}$				N_3				
e:	$12\bar{3}2$	$21\bar{1}$	×							Z_9, Z_{12}
f:	$4\cdot10\cdot\bar{1}4\cdot9$	$95\bar{5}$					N_4			
g:	$26\bar{8}5$	$53\bar{3}$			N_2					
g:	$14\bar{5}3$	$32\bar{2}$		N_1						
h:	$2\cdot10\cdot\bar{1}2\cdot7$	$75\bar{5}$				N_3				
i:	$16\bar{7}4$	$43\bar{3}$			N_2					
f:	$18\bar{9}5$	$54\bar{4}$				N_3				
u:	$1\cdot10\cdot\bar{1}1\cdot6$	$65\bar{5}$					N_4			
m:	$1\cdot16\cdot\bar{1}7\cdot9$	$98\bar{8}$							?	
p:	$17\bar{8}3$	$43\bar{4}$				N_3				
n:	$15\bar{6}2$	$32\bar{3}$			N_2					
a:	$2\cdot8\cdot\bar{1}0\cdot3$	$53\bar{5}$				N_3				
p:	$13\bar{4}1$	$21\bar{2}$		N_1						Z_{11}, Z_{13}
q:	$24\bar{6}1$	$31\bar{3}$			N_2					Z_7, Z_{10}
t:	$8\cdot14\cdot\bar{2}\bar{2}\cdot3$	$11\cdot3\cdot\bar{1}\bar{1}$						N_5		
r:	$35\bar{8}1$	$41\bar{4}$				N_3				
i:	$4\cdot6\cdot\bar{1}0\cdot1$	$51\bar{5}$					N_4			

87 Whitlock, H. P., N. Y. State Museum Memoir **13**, Plate X, Fig. 4 (1910).

$\mathfrak{f}\colon (4\cdot 6\cdot \bar{1}\bar{0}\cdot 1) = (51\bar{5})$. This scalenohedron was also described by Whitlock [88] on crystals from Rossie and Lyon Mountains, N. Y. In both of the above occurrences the form agrees well in zonal relations with other forms present on the combinations. It also falls at the intersection of several well marked zones on the general projection and is referable to normal series N_4. It may be regarded as fairly well established.

Zone 6 = Z_6 Scalenohedrons of the Zone $[02\bar{2}1 : 40\bar{4}1]$

$\frac{h+k}{l}$ (Miller) = 2. Symbol $\frac{h}{k}$.

In this section of the zone $[02\bar{2}1 : 40\bar{4}1 : 11\bar{2}0] = [11\bar{1} : 11\bar{3} : 10\bar{1}]$ a knot obviously falls at the pole $(21\bar{3}1) = (20\bar{1})$. Splitting at this point and developing the zone fragment between $(11\bar{1})$ and $(20\bar{1})$ we have:

Form	$\varphi\cdot 11\bar{1}$	$\mathfrak{A}: 75\bar{6}$	$\mathfrak{O}: 13\cdot 9\cdot \bar{1}\bar{1}$	$\mathfrak{B}: 64\bar{5}$	$\mathfrak{Q}: 11\cdot 7\cdot \bar{9}$	$\mathfrak{C}: 53\bar{4}$	$\mathfrak{D}: 95\bar{7}$
Symbol	1	$\frac{7}{5}$	$\frac{13}{9}$	$\frac{3}{2}$	$\frac{11}{7}$	$\frac{5}{3}$	$\frac{9}{5}$
$v-1$	0	$\frac{2}{5}$	$\frac{4}{9}$	$\frac{1}{2}$	$\frac{4}{7}$	$\frac{2}{3}$	$\frac{4}{5}$
N_4	0 ..	$\frac{2}{5}$	$(\frac{4}{9})$	$\frac{1}{2}$	$(\frac{4}{7})$.	$\frac{2}{3}$.	$(\frac{4}{5})$

Form	$\mathfrak{E}: 42\bar{3}$	$\mathfrak{F}: 73\bar{5}$	$\mathfrak{G}: 31\bar{2}$	α $51\bar{3}$	$\mathfrak{H}: 13\cdot 1\cdot \bar{7}$	$K: 20\bar{1}$
Symbol	2	$\frac{7}{3}$	3	5	13	∞
$v-1$	1	$\frac{4}{3}$	2	4	12	∞
N_4	1	$\frac{4}{3}$ ..	2 ..	4	(12)	∞

This fragment of the zone referred to N_4 is quite incomplete and contains the extra forms, $\frac{13}{9}$, $\frac{11}{7}$, $\frac{9}{5}$ and 13.

$\mathfrak{O}\colon (4\cdot 20\cdot \bar{2}\bar{4}\cdot 11) = (13\cdot 9\cdot \bar{1}\bar{1})$. This scalenohedron was recorded by Melczer [89] on crystals from the vicinity of Budapest. Apart from the fact that this form falls in a high normal series, the zonal relations of this pole do not indicate a high degree of probability. The form should be classed as doubtful.

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88 Whitlock, H. P., N. Y. State Museum Memoir, **13**, Plate III, Figs. 3 and 4, and Plate X, Fig. 1 (1910).

89 Melczer, G., Föld. Közlöny, **27**, 79 (1896).

$\mathfrak{Q}$: $(4\cdot16\cdot\bar{2}\bar{0}\cdot9) = (11\cdot7\cdot\bar{9}.)$. This scalenohedron was noted by Sansoni [90] on crystals associated with the pink apophyllite of pyramidal habit from Andreasberg. The measured angles as recorded by Sansoni agree well with theory. Further, the form which falls in normal series N_5 marks the intersection of the zones $[71\bar{8}9 : 04\bar{4}1]$ and $[0001 : 14\bar{5}0]$ both of which are well marked. The form is quite probable.

$\mathfrak{D}$: $(4\cdot12\cdot\bar{1}\bar{6}\cdot7) = (95\bar{7})$. This scalenohedron was recorded by Cesàro [91] on two crystals from Rhisnes, Belgium. The faces measured by Cesàro were small and ill defined. The form however falls in normal series N_5 and marks the intersections of the zones $[40\bar{4}7 : 01\bar{1}0]$ and $[51\bar{6}7 : 08\bar{8}1]$. It is somewhat less probable than the preceding form.

$\mathfrak{H}$: $(12\cdot8\cdot\bar{2}\bar{0}\cdot7) = (13\cdot1\cdot\bar{7})$. This scalenohedron was noted by Hessenberg [92] on crystals from Matlock, Derbyshire. The form was included in Irby's list without comment. Although falling in a high normal series it marks the intersection of several fairly well marked zones. It is fairly probable.

In the zone fragment between $(20\bar{1})$ and $(11\bar{3})$ only two scalenohedrons have been recorded.

Form	K: $20\bar{1}$	O: $7\bar{1}\bar{3}$	Π: $8\bar{2}\bar{3}$	*m*. $11\bar{3}$
Symbol	∞	7	4	1
$\frac{v-1}{3}$	∞	2	1	0
N_2	∞	2	1	0

Referred to N_2 this zone fragment lacks the term $\frac{1}{2}$ but contains no extra forms.

ZONE 6 = Z_6 SCALENOHEDRONS OF THE ZONE $[40\bar{4}1 : 11\bar{2}0] = [11\bar{3} : 10\bar{1}]$

$\frac{h-l}{k}$ (MILLER) = 2. SYMBOL $\frac{h}{k}$

The principal zone intersection in this section of Zone 6 is the pole of the relatively common scalenohedron $(62\bar{8}1) = (5\bar{1}\bar{3})$. Splitting

90 Sansoni, F., R. Acad. d. Linc., **19**, Plate III, Fig. 29 (1884).
91 Cesàro, G., loc. cit., Fig. 34.
92 Hessenberg, F., Min. Not., **4** (1863).

at this point and considering the forms of the fragment between $(11\bar{3})$ and $(5\bar{1}3)$ we have:

Form	m· $11\bar{3}$	Γ: $13\cdot\bar{4}\cdot\bar{5}$	Δ: $10\cdot\bar{3}\cdot\bar{4}$	Σ: $17\cdot\bar{5}\cdot\bar{7}$	Θ: $31\cdot\bar{9}\cdot\bar{1}3$	Φ: $7\bar{2}3$
Symbol	3	$\frac{13}{4}$	$\frac{10}{3}$	$\frac{17}{5}$	$\frac{31}{9}$	$\frac{7}{2}$
$v-3$	0	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{2}{5}$	$\frac{4}{9}$	$\frac{1}{2}$
$\frac{v^1}{v^1{}_2 - v^1}$	0	$\frac{1}{7}$	$\frac{1}{5}$	$\frac{1}{4}$	$\frac{2}{7}$	$\frac{1}{3}$
N_4	0	$(\frac{1}{7})$	$(\frac{1}{5})$	$\frac{1}{4}$	$(\frac{2}{7})$	$\frac{1}{3}$

Form	Λ: $25\cdot\bar{7}\cdot\bar{1}1$	Ξ: $11\cdot\bar{3}\cdot\bar{5}$	$\mathfrak{P}$: $4\bar{1}2$	$\mathfrak{M}$: $13\cdot\bar{3}\cdot\bar{7}$	$\mathfrak{N}$: $9\bar{2}5$	$\mathfrak{J}$: $5\bar{1}3$
Symbol	$\frac{25}{7}$	$\frac{11}{3}$	4	$\frac{13}{3}$	$\frac{9}{2}$	5
$v-3$	$\frac{4}{7}$	$\frac{2}{3}$	1	$\frac{4}{3}$	$\frac{3}{2}$	2
$\frac{v^1}{v^1{}_2 - v^1}$	$\frac{2}{5}$	$\frac{1}{2}$	1	2	3	∞
N_4	$\frac{2}{5}$	$\frac{1}{2}$ ···	1 ···	2 ·	3 ·	∞

Referred to N_4 this zone fragment is very incomplete and contains the extra forms $\frac{13}{4}$, $\frac{10}{3}$, and $\frac{31}{9}$.

Γ: $(17\cdot1\cdot\bar{1}\bar{8}\cdot4) = (13\cdot\bar{4}\cdot\bar{5})$. This scalenohedron is figured by Palache [93] on three crystals of different habit from the Lake Superior region of Michigan. Although this form falls in a high normal series its zonal relations are good, the pole lying at the intersection of several well marked zones. The form is probable.

Δ: $(13\cdot1\cdot\bar{1}\bar{4}\cdot3) = (10\cdot\bar{3}\cdot\bar{4})$. This scalenohedron was also recorded by Palache [94] on crystals from Lake Superior. It is figured as a series of very narrow planes. The form falls in normal series N_5 and shows better zonal relations than the previously discussed scalenohedron for the same occurrence. The form is probable.

Θ: $(40\cdot4\cdot\bar{4}\bar{4}\cdot9) = (31\cdot\bar{9}\cdot\bar{1}\bar{3})$. Like the two preceding forms, this scalenohedron was recorded by Palache on crystals from Lake Superior. It appears to be less probable than the two preceding forms.

The zone fragment between $(62\bar{8}1) = (5\bar{1}\bar{3})$ and $(11\bar{2}0) = (10\bar{1})$ contains the following recorded forms:

93 Palache, C., Geol. Surv. Mich., **6**, Fig. 3, 14 and 19 (1900).
94 Palache, C., Geol. Surv. Mich., **6**, Fig. 5 (1900).

Form	$\mathfrak{Z}$: $5\bar{1}\bar{3}$	$\mathfrak{C}$: $13\cdot\bar{2}\cdot\bar{9}$	$\mathfrak{K}$: $7\bar{1}\bar{5}$	$\mathfrak{T}$: $15\cdot\bar{2}\cdot\bar{1}\bar{1}$	a $10\bar{1}$
Symbol	5	$\frac{13}{2}$	7	$\frac{15}{2}$	∞
$v-6$	0	$\frac{1}{2}$	1	$\frac{3}{2}$	∞
N_2	0	$\frac{1}{2}$	1	$(\frac{3}{2})$	∞

Referred to N_2 this zone fragment lacks the number 2 and contains the extra form $\frac{15}{2}$.

Zone 6 = Z_6 Scalenohedrons of the zone $(02\bar{2}1 : 40\bar{4}1 : 11\bar{2}0]$

Letter	Bravais	Miller	Knot	N_1	N_2	N_3	N_4	N_5	?	Zone intersections
$\mathfrak{A}$:	$2\cdot11\cdot\bar{1}\bar{3}\cdot6$	$75\bar{6}$					N_4			
$\mathfrak{O}$:	$4\cdot20\cdot\bar{2}\bar{4}\cdot11$	$13\cdot9\cdot\bar{1}\bar{1}$							?	
$\mathfrak{B}$:	$2\cdot9\cdot\bar{1}\bar{1}\cdot5$	$64\bar{5}$			N_2					
$\mathfrak{Q}$:	$4\cdot16\cdot\bar{2}\bar{0}\cdot9$	$11\cdot7\cdot\bar{9}$						N_5		
$\mathfrak{C}$:	$27\bar{9}4$	$53\bar{4}$				N_3				
$\mathfrak{D}$:	$4\cdot12\cdot\bar{1}\bar{6}\cdot7$	$95\bar{7}$						N_5		
$\mathfrak{E}$:	$25\bar{7}3$	$42\bar{3}$		N_1						Z_9
$\mathfrak{F}$:	$4\cdot8\cdot\bar{1}\bar{2}\cdot5$	$73\bar{5}$					N_4			
$\mathfrak{G}$:	$23\bar{5}2$	$31\bar{2}$			N_2					Z_8
$\mathfrak{H}$:	$12\cdot8\cdot\bar{2}\bar{0}\cdot7$	$13\cdot1\cdot\bar{7}$							?	
O:	$8\cdot2\cdot\bar{1}\bar{0}\cdot3$	$7\bar{1}3$			N_2					
Π:	$10\cdot1\cdot\bar{1}\bar{1}\cdot3$	$8\bar{2}3$		N_1						
Γ:	$17\cdot1\cdot\bar{1}\bar{8}\cdot4$	$13\cdot\bar{4}\cdot\bar{5}$							?	
Δ:	$13\cdot1\cdot\bar{1}\bar{4}\cdot3$	$10\cdot\bar{3}\cdot\bar{4}$						N_5		
Σ:	$22\cdot2\cdot\bar{2}\bar{4}\cdot5$	$17\cdot\bar{5}\cdot\bar{7}$					N_4			
Θ:	$40\cdot4\cdot\bar{4}\bar{4}\cdot9$	$31\cdot\bar{9}\cdot\bar{1}\bar{3}$						N_5		
Φ:	$9\cdot1\cdot\bar{1}\bar{0}\cdot\bar{2}$	$7\bar{2}\bar{3}$				N_3				
Λ:	$32\cdot2\cdot\bar{3}\bar{6}\cdot7$	$25\cdot\bar{7}\cdot\bar{1}\bar{1}$					N_4			
Ξ:	$14\cdot2\cdot\bar{1}\bar{6}\cdot3$	$11\cdot\bar{3}\cdot\bar{5}$			N_2					
Ψ:	$51\bar{6}1$	$4\bar{1}\bar{2}$		N_1						Z_{13}
$\mathfrak{M}$:	$16\cdot4\cdot\bar{2}\bar{0}\cdot3$	$13\cdot\bar{3}\cdot\bar{7}$			N_2					
$\mathfrak{N}$:	$11\cdot3\cdot\bar{1}\bar{4}\cdot2$	$9\bar{2}\bar{5}$				N_3				
$\mathfrak{Z}$:	$62\bar{8}1$	$5\bar{1}\bar{3}$	×		•					Z_{10}
$\mathfrak{S}$:	$15\cdot7\cdot\bar{2}\bar{2}\cdot2$	$13\cdot\bar{2}\cdot\bar{9}$			N_2					
$\mathfrak{K}$:	$8\cdot4\cdot\bar{1}\bar{2}\cdot1$	$7\bar{1}\bar{5}$		N_1						
$\mathfrak{T}$:	$17\cdot9\cdot\bar{2}\bar{6}\cdot2$	$15\cdot\bar{2}\cdot\bar{1}\bar{1}$				N_3				

$\mathfrak{T}$: $(17\cdot9\cdot\overline{26}\cdot2) = (15\cdot\overline{2}\cdot\overline{11})$. This scalenohedron was recorded by Cesàro on two crystals from Rhisnes, Belgium. The measured angles given by Cesàro agree well with theory and the form, which falls in normal series N_3 presents good zonal relations. It should be ranked as probable.

ZONE 7 = Z_7 SCALENOHEDRONS OF THE ZONE $(40\overline{4}1 : 08\overline{8}1] = [3\overline{11} : 33\overline{5}]$. $\frac{k+l}{h}$ (MILLER) $= \frac{2}{3}$. SYMBOL $\frac{k}{l}$.

The most prominent zone intersection in this zone occurs at the pole $(32\overline{5}1) = (30\overline{2})$. Splitting the zone at this point we have for the recorded forms in the fragment between $(3\overline{11})$ and $30\overline{2})$:

Form	$\{m.$ $\{3\overline{11}$	$6\overline{13}$	$\mathfrak{U}$: $21\cdot\overline{3}\cdot\overline{11}$	U: $\overline{9}1\overline{5}$	$\mathfrak{B}$: $15\cdot\overline{1}\cdot\overline{9}$	$\mathfrak{Y}$: $18\cdot\overline{1}\cdot\overline{11}$	P: $30\overline{2}$
Symbol	1	$\frac{1}{3}$	$\frac{3}{11}$	$\frac{1}{5}$	$\frac{1}{9}$	$\frac{1}{11}$	0
$\frac{v-v_1}{v}$	0	2	$\frac{8}{3}$	4	8	10	∞
$\frac{v^1}{4}$	0	$\frac{1}{2}$	$\frac{2}{3}$	1	2	$\frac{5}{2}$	∞
N_3	0 ·	$\frac{1}{2}$	$\frac{2}{3}$ ·	1 ·	2	$(\frac{5}{2})$ ·	∞

Referred to N_3 this fragment of the zone is incomplete and contains the extra form $\frac{1}{11}$.

$\mathfrak{Y}$: $(19\cdot10\cdot\overline{29}\cdot6) = (18\cdot\overline{1}\cdot\overline{11})$. This scalenohedron was recorded by Cesàro [95] on crystals from Rhisnes, Belgium. Cesàro points out the proximity of this form to $(16\cdot8\cdot\overline{24}\cdot5)$ which is present on the same occurrence but contends that the measured angles and zonal relations point to the given indices. The form falls in normal series N_4 and should be classed as fairly probable.

In the fragment of the zone between $(30\overline{2})$ and $(33\overline{5})$ the following forms have been recorded:

Form	$\{P$: $\{30\overline{2}$	$\mathfrak{U}$ $15\cdot1\cdot\overline{11}$	γ $91\overline{7}$	$\mathfrak{M}$ $12\cdot3\cdot\overline{11}$	$\mathfrak{q}$: $31\overline{3}$	$\mathfrak{X}$: $9\cdot5\cdot\overline{11}$	$\mathfrak{L}$: $32\overline{4}$	Π. $33\overline{5}$
Symbol	0	$\frac{1}{11}$	$\frac{1}{7}$	$\frac{3}{11}$	$\frac{1}{3}$	$\frac{5}{11}$	$\frac{1}{2}$	$\frac{3}{5}$
$\frac{v}{v_2-v}$	0	$\frac{5}{28}$	$\frac{5}{16}$	$\frac{5}{6}$	$\frac{5}{4}$	$\frac{25}{8}$	5	∞
$\frac{4v'}{5}$	0	$\frac{1}{7}$	$\frac{1}{4}$	$\frac{2}{3}$	1	$\frac{5}{2}$	4	∞
N_4	0	$(\frac{1}{7})$	$\frac{1}{4}$	$\frac{2}{3}$ ·	1	$\frac{5}{2}$ ·	4	∞

[95] Cesàro, G., loc. cit., Fig. 54.

Referred to N_4 this zone fragment is very incomplete and contains the extra form $\frac{1}{11}$. The forms γ $(91\bar{7})$ and $\mathfrak{q}$: $(31\bar{3})$ have already been discussed under Z_2 and Z_5 respectively.

$\mathfrak{U}$ $(14\cdot12\cdot\bar{2}\bar{6}\cdot5) = (15\cdot1\cdot\bar{1}\bar{1})$. This scalenohedron was recorded by Whitlock [96] on crystals from Lyon Mountain, N. Y. Although agreeing fairly well with regard to measured and calculated angles this form falls in a rather high normal series. The form must be regarded as somewhat doubtful.

Hypothetical scalenohedrons.— In the above series the missing term 2 corresponds to the hypothetical scalenohedron $(3\cdot10\cdot\bar{1}\bar{3}\cdot2) = (63\bar{7})$. A pole corresponding to these indices would lie at the intersection of zone Z_7 with $[31\bar{4}2 : 01\bar{1}0]$, $[05\bar{5}1 : 10\bar{1}0]$ and $[10\bar{1}4 : 27\bar{9}1]$ all of which are fairly well marked with rational forms. $(3\cdot10\cdot\bar{1}\bar{3}\cdot2)$ should be retained as a hypothetical form.

ZONE 8 = Z_8. — SCALENOHEDRONS OF THE ZONE $[01\bar{1}2 : 11\bar{2}\bar{0}] = [110 : 10\bar{1}]$. $\frac{h-k}{l}$ (MILLER) = 1. SYMBOL $\frac{h}{k}$.

This zone is susceptible of development without splitting. The recorded forms are as follows:

Form	δ. 110	$\mathfrak{e}$: $21\bar{1}$	a : $94\bar{5}$	b : $52\bar{3}$	$\mathfrak{G}$: $31\bar{2}$	c : $41\bar{3}$	d : $51\bar{4}$	e : $11\cdot2\cdot\bar{9}$	g : $71\bar{6}$	a $10\bar{1}$
Symbol	1	2	$\frac{9}{4}$	$\frac{5}{2}$	3	4	5	$\frac{11}{2}$	7	∞
$\frac{v-1}{2}$	0	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	1	$\frac{3}{2}$	2	$\frac{9}{4}$	3	∞
N_4	$0\cdots\frac{1}{2}$	$\cdot$	$(\frac{5}{8})$	$\cdot\frac{3}{4}$	1	$\cdot\frac{3}{2}\cdot$	2	$(\frac{9}{4})$	$\cdot$ 3	$\cdot\infty$

Referred to N_4 this zone is incomplete and contains the extra forms $\frac{9}{4}$ and $\frac{11}{2}$.

a : $(5\cdot9\cdot\bar{1}\bar{4}\cdot8) = (94\bar{5})$. This scalenohedron was recorded as Hessenberg [97] on crystals from the Canary Islands. Irby, who has reinvestigated this occurrence, regards the face to which these indices were attached by Hessenberg as utterly indeterminable. The form is very doubtful.

e : $(9\cdot11\cdot\bar{2}\bar{0}\cdot4) = (11\cdot2\cdot\bar{9})$. This scalenohedron was also determined by Hessenberg [98] on crystals from Matlock, Derbyshire. Irby

96 Whitlock, H. P., Zeit. f. Kryst., **43**, Fig. 5 and 8 (1907).
97 Hessenberg, F., Min. Notiz., **7** (1866).
98 Hessenberg, F., Min. Notiz., **4** (1863).

includes this form in his list without comment. It marks the intersection of the zones $[50\bar{5}1 : 05\bar{5}1]$, $[3\bar{1}\bar{2}1 : 24\bar{6}1]$ and $[13\bar{4}1 : 62\bar{8}1]$ all of which contain well established forms. The form may be considered as fairly probable.

ZONE 9 = Z_9. — SCALENOHEDRONS OF THE ZONE $[01\bar{1}1 : 11\bar{2}0] = [22\bar{1} : 10\bar{1}]$. $\frac{h-l}{k}$ (MILLER) $= \frac{1}{2}$. SYMBOL $\frac{h}{k}$.

Like the preceding, this zone is susceptible of development without splitting. The following forms have been recorded:

Form	$\kappa \cdot 22\bar{1}$	$\mathfrak{g}$ $32\bar{2}$	Λ $16\cdot10\cdot\bar{1}\bar{1}$	Σ $13\cdot8\cdot\bar{9}$	$\mathfrak{Q}$ $74\bar{5}$	$\mathfrak{F}$ $42\bar{3}$
Symbol	1	$\frac{3}{2}$	$\frac{8}{5}$	$\frac{13}{8}$	$\frac{7}{4}$	2
$v-1$	0	$\frac{1}{2}$	$\frac{3}{5}$	$\frac{5}{8}$	$\frac{3}{4}$	1
N_4	0 ···	$\frac{1}{2}$	$\frac{3}{5}$	$(\frac{5}{8})$ ·	$\frac{3}{4}$	1

Form	F $94\bar{7}$	Θ $52\bar{4}$	Π $62\bar{5}$	Ω $13\cdot4\cdot\bar{1}\bar{1}$	Ψ $82\bar{7}$	a $10\bar{1}$
Symbol	$\frac{9}{4}$	$\frac{5}{2}$	3	$\frac{13}{4}$	4	∞
$v-1$	$\frac{5}{4}$	$\frac{3}{2}$	2	$\frac{9}{4}$	3	∞
N_4 ·	$(\frac{5}{4})$ ·	$\frac{3}{2}$ ·	2	$(\frac{9}{4})$ ·	3 ·	∞

Referred to N_4 this zone is incomplete and contains the extra forms $\frac{13}{8}$, $\frac{9}{4}$ and $\frac{13}{4}$.

Σ $(5\cdot17\cdot\bar{2}\bar{2}\cdot12) = (13\cdot8\cdot\bar{9})$. This scalenohedron was observed by Höfer [99] on crystals from Rauris near Salzburg. The form falls in normal series N_5 and presents some fairly good zonal relations. It is somewhat probable.

F $(5\cdot11\cdot\bar{1}\bar{6}\cdot6) = (94\bar{7})$. This scalenohedron was noted by Palache [100] on one crystal from the Lake Superior region of Michigan. Palache's figure shows this form developed to a series of planes of fair size and suggests that the form may lie in zone with $(2\cdot9\cdot\bar{1}\bar{1}\cdot5)$ and $(10\cdot1\cdot\bar{1}\bar{1}\cdot0)$, both of which are present on the combination. This zonal relation does not, however, hold. The form which falls in

99 Höfer, H., Min. Mitth., **12**, 487 (1891).
100 Palache, C., Geol. Surv. Mich., **6**, Plate 13, Fig. 11 (1900).

normal series N_5 marks the intersection of the zones $[02\bar{2}1 : 10\cdot0\cdot\bar{1}0\cdot1]$, $[40\bar{4}7 : 17\bar{8}0]$ and $[13\bar{4}2 : 07\bar{7}2]$. It is very probable.

$\Omega\,(35\bar{8}2) = (13\cdot4\cdot\bar{1}\bar{1})$. This scalenohedron was noted by Flink [101] on crystals from Narsarsuk, southern Greenland. In spite of the high normal series to which this form is referable, it presents excellent zonal relations and should be regarded as fairly probable.

ZONE 10 = Z_{10}. — SCALENOHEDRONS OF THE ZONE $[05\bar{5}1 : 10\cdot0\cdot\bar{1}0\cdot1]$.

This zone contains only one scalenohedron which has not already been discussed in the preceding analysis, namely: $X : (16\cdot7\cdot\bar{2}\bar{3}\cdot3) = (14\cdot\bar{2}\cdot\bar{9})$. This scalenohedron was observed by Eakle on a series of crystals from the cinnabar mine at Terlingua, Texas. The form was noted on all the crystals studied and although developed as slightly rounded planes gave good agreement between measured and calculated angles. Moreover the form marks the intersection of the zones $[11\cdot0\cdot\bar{1}\bar{1}\cdot\bar{1} : 32\bar{5}1]$ and $[11\bar{2}3 : 21\bar{3}1]$ all four of which forms are present on the combination. The form is well established.

ZONE 11 = Z_{11}. — SCALENOHEDRONS OF THE ZONE $[50\bar{5}2 : 05\bar{5}1] = [11\bar{4} : 22\bar{3}]$. SYMBOL $\frac{h}{l}$.

In this portion of the zone $[50\bar{5}2 : 05\bar{5}1 : 1120]$ the most prominent pole is $(21\bar{3}1) = (20\bar{1})$. Splitting at this point and considering the fragment between $(20\bar{1})$ and $(22\bar{3})$ in as much as no forms have been recorded between $(11\bar{4})$ and $(20\bar{1})$, we have for the forms recorded:

Form	K: $20\bar{1}$	c: $41\bar{3}$	Π $62\bar{5}$	$\Re$: $83\bar{7}$	$\mathfrak{p}$: $21\bar{2}$	Ξ. $22\bar{3}$
Symbol	2	$\frac{4}{3}$	$\frac{6}{5}$	$\frac{8}{7}$	1	$\frac{2}{3}$
$\frac{v - v_1}{v_2 - v}$	0	1	$\frac{3}{2}$	$\frac{9}{5}$	3	∞
$\frac{v^1}{3}$	0	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{3}{5}$	1	∞
N_3	0	$\frac{1}{3}$	$\frac{1}{2}$	$(\frac{3}{5})$ ·	1 ···	∞

Referred to N_3 this zone fragment is incomplete and contains the extra form $\frac{8}{7}$.

101 Flink, G., Medd. om Grönl., **24** (1899).

$\mathfrak{R}$: $(5\cdot10\cdot\bar{1}\bar{5}\cdot4) = (83\bar{7})$. This scalenohedron was observed by Sansoni [102] on crystals from Andreasberg. Although the angles measured by Sansoni do not agree very well with theory, the form marks the intersection of the zone $[05\bar{5}4 : 11\bar{2}0]$, a relation which was noted by Sansoni. The form moreover, falls in normal series N_4. It should be ranked as probable.

Hypothetical scalenohedrons. In the above series the missing term 2 corresponds to the hypothetical scalenohedron $(2\cdot11\cdot\bar{1}\bar{3}\cdot3) = (64\bar{7})$. This form marks the intersection of the zones $[20\bar{2}3 : 01\bar{1}0]$, $[03\bar{3}1 : 11\bar{2}0]$ and $[04\bar{4}1 : 80\bar{8}1]$ all of which are marked by rational and well established forms. The form should be retained as hypothetical.

In the portion of the zone included between $(05\bar{5}1) = (22\bar{3})$ and $(11\bar{2}0) = (10\bar{1})$ the following forms have been recorded:

Form	Ξ. $22\bar{3}$	$\mathfrak{e}$ $54\bar{7}$	$\mathfrak{L}$: $32\bar{4}$	$\mathfrak{v}$ $42\bar{5}$	a $10\bar{1}$
Symbol	$\frac{2}{3}$	$\frac{5}{7}$	$\frac{3}{4}$	$\frac{4}{5}$	1
$\frac{v - v^1}{v_2 - v}$	0	$\frac{1}{6}$	$\frac{1}{3}$	$\frac{2}{3}$	∞
$3v^1$	0	$\frac{1}{2}$	1	2	∞
N_2	0	$\frac{1}{2}$	1	2	∞

Referred to N_2 this portion of the zone is complete and contains no extra forms.

ZONE 12 = Z_{12}.— SCALENOHEDRONS OF THE ZONE $[05\bar{5}4 : 50\bar{5}2]$.

This zone contains only one scalenohedron which has not already been discussed in the analysis of the preceding zones, namely:

$\mathfrak{W}$ $(7\cdot4\cdot\bar{1}\bar{1}\cdot6) = (81\bar{3})$. This scalenohedron was observed by Palache [103] on crystals from the Lake Superior region of Michigan. On the combination figured by Palache, the form occurs with $(20\cdot11\cdot\bar{3}\bar{1}\cdot15)$ and $(37\cdot19\cdot\bar{5}\bar{6}\cdot21)$ in a zone extending from $[11\bar{2}3 : 21\bar{3}1] = [\frac{2}{3}P_2 : R_3]$ not $[R : R_3]$ as stated by Palache. The form also falls in zones $[02\bar{2}3 : 10\bar{1}0]$ and $[41\bar{5}3 : 03\bar{3}1]$. It may be regarded as well established.

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102 Sansoni, F., Accad. d. Linc. Mem. **19** (1884).
103 Palache, C., Geol. Surv. Mich., **6**, Plate XII, Fig. 5 (1900).

ZONE 13 = Z_{13}.— SCALENOHEDRONS OF THE ZONE $[07\bar{7}2 : 70\bar{7}1] = [33\bar{4} : 5\bar{2}\bar{2}]$. SYMBOL $\frac{h}{k}$.

Developing the recorded forms of this zone into a series we have:

	$\Delta\cdot$	$Q\colon$	$\mathfrak{p}\colon$	$V\colon$	$d\colon$	β	$P\colon$	$\mathfrak{P}\colon$	$q\cdot$
Form	$33\bar{4}$	$17\cdot10\cdot\bar{1}8$	$21\bar{2}$	$29\cdot10\cdot\bar{2}6$	$51\bar{4}$	$81\bar{6}$	$30\bar{2}$	$41\bar{2}$	$5\bar{2}\bar{2}$
Symbol	1	$\frac{17}{10}$	2	$\frac{29}{10}$	5	8	∞	4	$\frac{5}{2}$
$v-1$	0	$\frac{7}{10}$	1	$\frac{19}{10}$	4	7	∞		
N_4	$0\cdots\cdots$	$(\frac{7}{10})$	$\cdots$ 1 $\cdots$	$(\frac{19}{10})$	$\cdots$ 4	(7)	∞		

Referred to N_4 the zone fragment between $(33\bar{4})$ and $(30\bar{2})$ is very incomplete and contains the extra forms $\frac{17}{10}$, $\frac{29}{10}$ and 8, of which the latter has already been discussed under zone 2. The portion of the zone between $(30\bar{2})$ and $5\bar{2}\bar{2})$ contains no forms which have not been already discussed.

$Q\colon (7\cdot28\cdot\bar{3}\bar{5}\cdot9) = (17\cdot10\cdot\bar{1}8)$. This scalenohedron was noted by Hessenberg [104] on crystals from Rödefiord, Iceland. Irby includes this form in his list without comment; it is somewhat worthy of note, however, that the hypothetical form $(6\cdot25\cdot\bar{3}1\cdot8) = (15\cdot9\cdot\bar{1}6)$ differs from $(7\cdot28\cdot\bar{3}\bar{5}\cdot9)$ by less than 20′ of φ value and by only 1′ of ρ value. This hypothetical scalenohedron would reduce to $\frac{2}{3}$ in the above series. The form $(7\cdot28\cdot\bar{3}\bar{5}\cdot9)$ is somewhat doubtful.

$V\colon (19\cdot36\cdot\bar{5}\bar{5}\cdot13) = (29\cdot10\cdot\bar{2}6)$. This scalenohedron was observed by Gonnard [105] on crystals from Couzon, Rhône, France. As in the previous instance it would seem that a hypothetical scalenohedron could be substituted for this form. The hypothetical form $(6\cdot11\cdot\bar{1}\bar{7}\cdot4) = (9\bar{3}\bar{8})$ gives the following values of φ and ρ compared with $(19\cdot36\cdot\bar{5}\bar{5}\cdot13)$:

	φ	ρ
$(6\cdot11\cdot\bar{1}\bar{7}\cdot4)$	39° 38′	74° 52′
$(19\cdot36\cdot\bar{5}\bar{5}\cdot13)$	40 7	74 46

The above hypothetical scalenohedron would reduce to 2 in the series under discussion. It is possible that the scalenohedron $(19\cdot36\cdot\bar{5}\bar{5}\cdot13)$ should be referred to the simpler indices.

104 Hessenberg, F., Min. Notiz., **8** (1872).
105 Gonnard, F., Bull. soc. fr. min., **20**, 18 (1897).

Zone 7 = Z_7 Scalenohedrons of the zone $[40\bar{4}1 : 08\bar{8}1]$										
Letter	Bravais	Miller	Knot	N_1	N_2	N_3	N_4	N_5	?	Zone intersections
n'	$72\bar{9}2$	$6\bar{1}\bar{3}$			N_2					Z_{12}
$\mathfrak{U}$	$24\cdot8\cdot\bar{3}\bar{2}\cdot7$	$21\cdot\bar{3}\cdot\bar{1}\bar{1}$				N_3				
U	$10\cdot4\cdot\bar{1}\bar{4}\cdot3$	$9\bar{1}\bar{5}$		N_1						
$\mathfrak{B}$	$16\cdot8\cdot\bar{2}\bar{4}\cdot5$	$15\cdot\bar{1}\cdot\bar{9}$			N_2					
$\mathfrak{Y}$	$19\cdot10\cdot\bar{2}\bar{9}\cdot6$	$18\cdot\bar{1}\cdot\bar{1}\bar{1}$					N_4			
$\mathfrak{U}$	$14\cdot12\cdot\bar{2}\bar{6}\cdot5$	$15\cdot1\cdot\bar{1}\bar{1}$							?	
$\mathfrak{M}$	$9\cdot14\cdot\bar{2}\bar{3}\cdot4$	$12\cdot3\cdot\bar{1}\bar{1}$				N_3				
$\mathfrak{X}$	$4\cdot16\cdot\bar{2}\bar{0}\cdot3$	$9\cdot5\cdot\bar{1}\bar{1}$					N_4			
$\mathfrak{P}$	$16\bar{7}1$	$32\bar{4}$					N_4			Z_{11}
Hypothetical scalenohedron of the zone $[40\bar{4}1 : 08\bar{8}1]$										
	$3\cdot10\cdot\bar{1}\bar{3}\cdot2$	$63\bar{7}$			N_2					
Zone 8 = Z_8 Scalenohedrons of the zone $[01\bar{1}2 : 11\bar{2}0]$										
a	$5\cdot9\cdot\bar{1}\bar{4}\cdot3$	$94\bar{5}$						N_5		
b	$35\bar{8}4$	$52\bar{3}$					N_4			
c	$34\bar{7}2$	$41\bar{3}$				N_3				Z_{11}
d	$45\bar{9}2$	$51\bar{4}$			N_2					Z_{13}
e	$9\cdot11\cdot\bar{2}\bar{0}\cdot4$	$11\cdot2\cdot\bar{9}$							?	
g	$6\cdot7\cdot\bar{1}\bar{3}\cdot2$	$71\bar{6}$				N_3				
Zone 9 = Z_9 Scalenohedrons of the zone $[01\bar{1}1 : 11\bar{2}0]$										
Λ	2795	$16\cdot10\cdot\bar{1}\bar{1}$					N_4			
Σ	$5\cdot17\cdot\bar{2}\bar{2}\cdot12$	$13\cdot8\cdot\bar{9}$						N_5		
Q	$13\bar{4}2$	$74\bar{5}$					N_4			
Φ	$5\cdot11\cdot\bar{1}\bar{6}\cdot6$	$94\bar{7}$						N_5		
Θ	$12\bar{3}1$	$52\bar{4}$				N_3				
Π	$4\cdot7\cdot\bar{1}\bar{1}\cdot3$	$62\bar{5}$			N_2					Z_{11}
Ω	$35\bar{8}2$	$13\cdot4\cdot\bar{1}\bar{1}$							?	
Ψ	$23\bar{5}1$	$82\bar{7}$				N_3				

Letter	Bravais	Miller	Knot	N_1	N_2	N_3	N_4	N_5	?	Zone intersections
Zone 10 = Z_{10} Scalenohedron of the zone $[05\bar{5}1 : 10\cdot0\cdot\bar{1}\bar{0}\cdot1]$										
X:	$16\cdot7\cdot\bar{2}\bar{3}\cdot3$	$14\cdot\bar{2}\cdot\bar{9}$								
Zone 11 = Z_{11} Scalenohedrons of the zone $[50\bar{5}2 : 05\bar{5}1 : 11\bar{2}0]$										
ℜ:	$5\cdot10\cdot\bar{1}\bar{5}\cdot4$	$83\bar{7}$					N_4			
e	$1\cdot11\cdot\bar{1}\bar{2}\cdot2$	$54\bar{7}$			N_2					
v	$27\bar{9}1$	$42\bar{3}$			N_2					
Hypothetical scalenohedron of the zone $[50\bar{5}2 : 05\bar{5}1 : 11\bar{2}0]$										
	$2\cdot11\cdot\bar{1}\bar{3}\cdot3$	$64\bar{7}$			N_2					
Zone 12 = Z_{12} Scalenohedrons of the zone $[05\bar{5}4 : 50\bar{5}2]$										
w	$7\cdot4\cdot\bar{1}\bar{1}\cdot6$	$81\bar{3}$								
Zone 13 = Z_{13} Scalenohedrons of the zone $[07\bar{7}2 : 70\bar{7}1]$										
Q:	$7\cdot28\cdot\bar{3}\bar{5}\cdot9$	$17\cdot10\cdot\bar{1}\bar{8}$							?	
V:	$19\cdot36\cdot\bar{5}\bar{5}\cdot13$	$29\cdot10\cdot\bar{2}\bar{6}$							?	
Hypothetical scalenohedrons of the zone $[07\bar{7}2 : 70\bar{7}1]$										
	$6\cdot25\cdot\bar{3}\bar{1}\cdot8$	$15\cdot9\cdot\bar{1}\bar{6}$				N_3				
	$6\cdot11\cdot\bar{1}\bar{7}\cdot4$	$93\bar{8}$			N_2					

In order to reduce as much as possible the number of forms which fall outside the limit of the discussion by developed zonal series, a number of supplementary zones have been chosen with a view to:

1° The importance of the limiting poles.

2° The number of forms included in the zone.

3° The number of forms not previously discussed which are included in the zone.

Accepting these conditions we pass to the discussion of these supplementary zones.

Scalenohedrons of the Zone $[20\bar{2}1 : 02\bar{2}1 : 10\bar{1}0] = [11\bar{5} : 11\bar{1} : 2\bar{1}\bar{1}]$. Symbol $\frac{k}{l}$.

In the portion of this zone between $(20\bar{2}1)$ and $(02\bar{2}1)$, an obvious knot occurs at $(31\bar{4}2) = (30\bar{1})$ which is also a knot point of zone 4.

4. Developing the fragment between $(30\bar{1})$ and $(11\bar{1})$ we have:

Form	$\{H:$ $\{30\bar{1}$	v $41\bar{2}$	$b:$ $52\bar{3}$	Q $74\bar{5}$	$\mathfrak{f}$ $15\cdot 9\cdot \bar{1}1$	$\mathfrak{E}$ $85\bar{6}$	V $17\cdot 11\cdot \bar{1}3$	t $96\bar{7}$	φ $11\bar{1}$
Symbol	0	$\frac{1}{2}$	$\frac{2}{3}$	$\frac{4}{5}$	$\frac{9}{11}$	$\frac{5}{6}$	$\frac{11}{13}$	$\frac{6}{7}$	1
$\frac{v}{v_2 - v}$	0	1	2	4	$\frac{9}{2}$	5	$\frac{11}{2}$	6	∞
$\frac{v^1}{2}$	0	$\frac{1}{2}$	1	2	$\frac{9}{4}$	$\frac{5}{2}$	$\frac{11}{4}$	3	∞
N_3	0	$\frac{1}{2}$	1	2	$(\frac{9}{4})$	$(\frac{5}{2})$	$(\frac{11}{4})$	3	∞

Referred to N_3 this zone fragment is very incomplete and contains the extra forms $\frac{9}{11}$ and $\frac{11}{13}$. $\frac{5}{6}$ falls in normal series N_4.

$\mathfrak{f}$ $(6\cdot 20\cdot \bar{2}6\cdot 13) = (15\cdot 9\cdot \bar{1}1)$. This scalenohedron was observed by Palache [106] on three crystals from the Lake Superior region of Michigan. On the combination cited it occurs developed to a considerable habit combined with $(14\bar{5}3)$ and $(4\cdot 20\cdot \bar{2}4\cdot 17)$, the three scalenohedrons lying in zone. This fact taken in conjunction with the perfect quality of the faces leaves little question as to the probability of the form.

V $(2\cdot 8\cdot \bar{1}0\cdot 5) = (17\cdot 11\cdot \bar{1}3)$. This scalenohedron was observed by Sansoni [107] on two crystals from Andreasberg. The form as measured by Sansoni agrees well with theory and marks the intersection of the zones $[06\bar{5} : 11\bar{2}0]$ and $[20\bar{2}5 : 01\bar{1}0]$. It should be regarded as fairly probable.

In the portion of the zone between $(02\bar{2}1)$ and $(10\bar{1}0)$ the principal zone intersection occurs at $(32\bar{5}1) = (30\bar{2})$ which developed as a knot

106 Palache, C., loc. cit., Plate XIV, Fig. 16.
107 Sansoni, F., loc. cit., Plate III, Fig. 25.

point in zone 4. Splitting at this point we have for the recorded forms in the first fragment:

Form	φ $11\bar{1}$	D $63\bar{5}$	A $11{\cdot}5{\cdot}\bar{9}$	Θ $52\bar{4}$	C: $41\bar{3}$	ξ $71\bar{5}$	P: $30\bar{2}$
Symbol	1	$\frac{3}{5}$	$\frac{5}{9}$	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{5}$	0
$\frac{v-v_1}{v}$	0	$\frac{2}{3}$	$\frac{4}{5}$	1	2	4	∞
N_3	0 ..	$\frac{2}{3}$	$(\frac{4}{5})$	1 ·	2 ·	(4)	∞

Referred to N_3 this zone fragment is incomplete and contains the extra forms $\frac{9}{5}$ and $\frac{1}{5}$, of which the latter has been discussed under zone 2.

A $(6{\cdot}14{\cdot}\bar{2}\bar{0}{\cdot}7) = (11{\cdot}5{\cdot}\bar{9})$. This scalenohedron was observed by Palache [108] on a single crystal from the Lake Superior region. On the combination cited it occurs in the zone under discussion which is here marked by $(02\bar{2}1)$ and $(62\bar{8}1)$. It also lies in zone with $(35\bar{8}4)$ and $(13\bar{4}1)$ both present on the combination, and falls in normal series N_5. The form is probable.

The following forms have been recorded between $(32\bar{5}1)$ and $(10\bar{1}0)$

Form	P: $30\bar{2}$	$\mathfrak{g}$ $47{\cdot}\bar{1}{\cdot}\bar{3}\bar{1}$	T $11{\cdot}\bar{1}{\cdot}\bar{7}$	$\mathfrak{H}$ $8\bar{1}\bar{5}$	$\mathfrak{m}$ $13{\cdot}\bar{2}{\cdot}\bar{8}$	$\mathfrak{Z}$ $5\bar{1}\bar{3}$	b $2\bar{1}\bar{1}$
Symbol	0	$\frac{1}{31}$	$\frac{1}{7}$	$\frac{1}{5}$	$\frac{1}{4}$	$\frac{1}{3}$	1
$\frac{v}{v_2-v}$	0	$\frac{1}{30}$	$\frac{1}{6}$	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{1}{2}$	∞
$2v'$	0	$\frac{1}{15}$	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{2}{3}$	1	∞
N_3	0	$(\frac{1}{15})$	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{2}{3}$	1 ···	∞

Referred to N_3 this zone fragment is complete up to the term 1 and contains the extra form $\frac{1}{31}$.

$\mathfrak{g}$ $(16{\cdot}10{\cdot}\bar{2}\bar{6}{\cdot}5) = (47{\cdot}\bar{1}{\cdot}\bar{3}\bar{1})$. This scalenohedron was observed by Johansson [109] on crystals from Norberg, Sweden. The form occurs on a somewhat complex combination (Type 3) close to the poles $(32\bar{5}1)$ and $(19{\cdot}13{\cdot}\bar{3}\bar{2}{\cdot}6)$ of zone 4. It should be classed as rather doubtful.

SCALENOHEDRONS OF THE ZONE $[1\bar{1}02 : 40\bar{4}7 : 17\bar{8}0] = [101 : 511 : 32\bar{5}]$

SYMBOL $\frac{k}{l}$.

Although oblique to the zone directions laid down in Plate I this zone is particularly well marked and is further emphasized by the fact

[108] Palache, C., loc. cit., Plate XII, Fig. 6.
[109] Johansson, K., Geol. Foren. Forh., **14**, 49 (1892).

of its having been observed in considerable completeness on at least two occurrences of calcite.[110] Splitting the zone at $(31\bar{4}5) = (40\bar{1})$ its point of intersection with zone 4 and developing the portion between $(40\bar{1})$ and $(32\bar{5})$ we have:

Form	w: $40\bar{1}$	λ $31\bar{1}$	b: $52\bar{3}$	$\mathfrak{F}$: $73\bar{5}$	F $94\bar{7}$	A $11\cdot5\cdot\bar{9}$	I $13\cdot6\cdot\bar{11}$
Symbol	∞	1	$\frac{2}{3}$	$\frac{3}{5}$	$\frac{4}{7}$	$\frac{5}{9}$	$\frac{6}{11}$
$\frac{v_2 - v}{v}$	∞	$\frac{3}{5}$	$\frac{2}{5}$	$\frac{1}{3}$	$\frac{3}{10}$	$\frac{7}{25}$	$\frac{4}{15}$
$5v^1$	∞	3	2	$\frac{5}{3}$	$\frac{3}{2}$	$\frac{7}{5}$	$\frac{4}{3}$
N_4	∞	3	2	$\frac{5}{3}$	$\frac{3}{2}$	$(\frac{7}{5})$	$\frac{4}{3}$

Form	J $15\cdot7\cdot\bar{13}$	i $17\cdot8\cdot\bar{15}$	Y $23\cdot11\cdot\bar{21}$	$\mathfrak{p}$: $21\bar{2}$	B $25\cdot13\cdot\bar{27}$	$\mathfrak{X}$: $9\cdot5\cdot\bar{11}$	σ $32\bar{5}$
Symbol	$\frac{7}{13}$	$\frac{8}{15}$	$\frac{11}{21}$	$\frac{1}{2}$	$\frac{13}{27}$	$\frac{5}{11}$	$\frac{2}{5}$
$\frac{v_2 - v}{v}$	$\frac{9}{35}$	$\frac{1}{4}$	$\frac{13}{55}$	$\frac{1}{5}$	$\frac{11}{65}$	$\frac{3}{25}$	0
$5v^1$	$\frac{9}{7}$	$\frac{5}{4}$	$\frac{13}{11}$	1	$\frac{11}{13}$	$\frac{3}{5}$	0
N_4	$(\frac{9}{7})$	$(\frac{5}{4})$	$(\frac{13}{11})$	1	$(\frac{11}{13})$	$\frac{3}{5}$	0

Referred to N_4 this zone fragment is incomplete and contains the extra forms $\frac{5}{9}$, $\frac{7}{13}$, $\frac{8}{15}$, $\frac{11}{21}$, and $\frac{13}{27}$. Of these the first, A $(6\cdot14\cdot\bar{20}\cdot7) = (11\cdot5\cdot\bar{9})$, has been discussed under the preceding zone, where, as in this case, it falls in normal series N_5.

J $(8\cdot20\cdot\bar{28}\cdot9) = (15\cdot7\cdot\bar{13})$. This scalenohedron was observed by Pirsson [111] on a single crystal supposed to have come from Mexico. In the combination figured by Pirsson the form is present in combination with $(4\cdot16\cdot\bar{20}\cdot3)$ and $(13\bar{4}1)$ of the zone under discussion although this zonal relation was not apparently tested in the gonimeter. The angles as measured agree well with theory and the pole lies at the intersection of the zones $[20\bar{2}1 : 04\bar{4}1]$ and $[0\bar{4}\bar{4}3 : 11\bar{2}0]$. The form is probable.

i $(9\cdot23\cdot\bar{32}\cdot10) = (17\cdot8\cdot\bar{15})$. This scalenohedron was observed by Gonnard [112] on crystals from Couzon, Rhône, France. The form occurs in normal series N_5 and marks the intersection of the zones

110 Palache, C., loc. cit., p. 177.
Whitlock, H. P., N. Y. State Mus. Bull. **133**, p. 219 (1909).
111 Pirsson, L.V., Am. Jour. Sci., **41**, 61 (1891).
112 Gonnard, F., Bull. soc. fr. min., **20**, 18 (1897).

$[0\cdot11\cdot\bar{1}\bar{1}\cdot4 : 11\cdot0\cdot\bar{1}\bar{1}\cdot2]$ and $[02\bar{2}1 : 31\bar{4}0]$. It should be classed as probable.

Y $(12\cdot32\cdot\bar{4}\bar{4}\cdot13) = (23\cdot11\cdot\bar{2}1)$. This scalenohedron was observed by vom Rath [113] on crystals from Bergen Hill, N. J. Irby includes it in his list without comment as does also Goldschmidt. In spite of the high normal series to which the form is referable it falls at the intersection of the zones $[02\bar{2}1 : 21\bar{3}0]$, $[\bar{1}4\bar{3}1 : 40\bar{4}1]$ and $[4\bar{1}\bar{3}2 : 05\bar{5}1]$ The form is probable.

B $(12\cdot40\cdot\bar{5}2\cdot11) = (25\cdot13\cdot\bar{2}\bar{7})$. This scalenohedron was observed by Palache [114] on two crystals from the Lake Superior region of Michigan. On the combination figured it is present as narrow face. It marks the intersection of the zone $[05\bar{5}1 : 40\bar{4}1]$ and is referable to the same normal series as the preceding form. The form is not as probable as those of this zone previously discussed.

Scalenohedrons of the Zone $[11\bar{2}3 : 13\bar{4}1] = [210 : 21\bar{2}]$. Symbol $\frac{k}{l}$.

Like the preceding, this zone is oblique to the directions of the zonal network. As limited in the present discussion it contains two knots of the zonal network and extended beyond $(11\bar{2}3)$ it includes $(0\bar{1}\bar{1}1)$ the most important pole of the system. Developing the fragment between $(11\bar{2}3)$ and $(13\bar{4}1)$ we have:

Form	π 210	e	*w*	$\mathfrak{E}$	*X*	*D*	$\mathfrak{p}$
		$21\bar{1}$	$63\bar{4}$	$42\bar{3}$	$10\cdot5\cdot\bar{8}$	$63\bar{5}$	$21\bar{2}$
Symbol	∞	1	$\frac{3}{4}$	$\frac{2}{3}$	$\frac{5}{8}$	$\frac{3}{5}$	$\frac{1}{2}$
$v-\frac{1}{2}$	∞	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{6}$	$\frac{1}{8}$	$\frac{1}{10}$	0
$2v^1$	∞	1	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{5}$	0
N_3	∞ ...	1 ·	$\frac{1}{2}$	$\frac{1}{3}$	$(\frac{1}{4})$	$(\frac{1}{5})$	0

Referred to N_3 this zone fragment is incomplete, specially as to the higher members of the series, and contains the extra forms $\frac{5}{8}$ and $\frac{3}{5}$, the latter of which has already been discussed.

X $(5\cdot13\cdot\bar{1}\bar{8}\cdot7) = (10\cdot5\cdot\bar{8})$. This scalenohedron was recorded by Lévy.[115] In commenting on this form Irby points out that the sub-

113 Vom Rath, G., Zeit. f. Kryst., **1**, 604 (1877).
114 Palache, C., loc. cit., Plate XIV, fig. 17.
115 A. Lévy, loc. cit., Fig. 138.

stitution of $(4\cdot13\cdot\bar{1}\bar{7}\cdot6) = (95\bar{8})$ for it by Descloizeaux is a somewhat arbitrary one. Descloizeaux' substitution seems to have been based upon the fact that $(4\cdot13\cdot\bar{1}\bar{7}\cdot6)$ marks the intersection of the zones $[31\bar{4}2 : 07\bar{7}2]$ and $[0552 : 50\bar{5}1]$. The assumed pole is at a considerable distance from $(5\cdot13\cdot\bar{1}\bar{8}\cdot7)$ in both φ and ρ values, several observed forms being nearer. $(5\cdot13\cdot\bar{1}\bar{8}\cdot7)$ is referable to normal series N_4 and marks the intersection of the zones $[2\bar{2}01 : 04\bar{4}1]$ and $[02\bar{2}1 : 51\bar{6}1]$, which in fact is a somewhat better zonal relation than that of Descloizeaux' assumed form. The form is probable.

Scalenohedrons of the Zone $[05\bar{5}1 : 50\bar{5}1 : 01\bar{1}0] = [22\bar{3} : 11\cdot\bar{4}\cdot\bar{4} : 11\bar{2}]$.

Splitting the first portion of this zone at $(32\bar{5}1) = (30\bar{2})$ which developed a knot in zone 4 and developing the fragment between $(30\bar{2})$ and $(11\cdot\bar{4}\cdot\bar{4})$ we have:

Form	P: $30\bar{2}$	S $13\cdot\bar{2}\cdot\bar{7}$	Φ: $7\bar{2}\bar{3}$	$n\cdot$ $11\cdot\bar{4}\cdot\bar{4}$
Symbol	∞	$\frac{7}{2}$	$\frac{3}{2}$	1
$v-1$	∞	$\frac{5}{2}$	$\frac{1}{2}$	0

In this development the form $(15\cdot5\cdot\bar{2}\bar{0}\cdot4) = (13\cdot\bar{2}\cdot\bar{7})$ stands in normal series N_4.

$S\,(15\cdot5\cdot\bar{2}\bar{0}\cdot4) = (13\cdot\bar{2}\cdot\bar{7})$. This scalenohedron is credited by Zippe[116] to Haidinger[117] on crystals from Derbyshire. The figure published by Zippe presents no zonal relations which would help in establishing the rank of probability of the form. Goldschmidt regards it as uncertain. On a basis of general zonal relations it should be ranked as fairly probable.

In the zone fragment between $(50\bar{5}1) = (11\cdot\bar{4}\cdot\bar{4})$ and $(54\bar{9}1) = (50\bar{4})$ the following forms have been recorded:

Form	$n\cdot$ $11\cdot\bar{4}\cdot\bar{4}$	$\mathfrak{P}$: $4\bar{1}2$	$\mathfrak{D}$ $37\cdot\bar{8}\cdot2\bar{0}$	$\mathfrak{C}$ $62\cdot\bar{1}3\cdot\bar{3}4$	$\mathfrak{v}$ $25\cdot\bar{5}\cdot\bar{1}4$	m: $13\cdot\bar{2}\cdot\bar{8}$	U: $50\bar{4}$
Symbol	1	2	$\frac{5}{2}$	$\frac{34}{13}$	$\frac{14}{5}$	4	∞
$v-1$	0	1	$\frac{3}{2}$	$\frac{21}{13}$	$\frac{9}{5}$	3	∞
N_3	0 ···	1 ·	$\frac{3}{2}$	$(\frac{21}{13})$	$(\frac{9}{5})$ ·	3	∞

116 Zippe, loc. cit., Fig. 5.
117 Haidinger, W., Leipzig (1829).

Referred to N_3 this zone fragment is incomplete and contains the extra forms $\frac{34}{13}$ and $\frac{14}{5}$.

$\mathfrak{C}$ $(25\cdot7\cdot\bar{3}\bar{2}\cdot5) = (62\cdot\bar{1}\bar{3}\cdot\bar{3}\bar{4})$. This scalenohedron was observed by Beykirch [118] on crystals from Dortmund, Prussia. This form falls very close to $(15\cdot4\cdot\bar{1}\bar{9}\cdot3) = (37\cdot\bar{8}\cdot\bar{2}\bar{0})$ and should possibly be referred to the simpler indices.

$\mathfrak{v}$ $(10\cdot3\cdot\bar{1}\bar{3}\cdot2) = (25\cdot\bar{5}\cdot\bar{1}\bar{4})$. This scalenohedron was recorded by Sansoni [119] on crystals from Freiberg. In spite of the relatively high normal series to which this form is referable, the fact that it lies in the well marked zone $[04\bar{4}1 : 80\bar{8}1]$ should class it as probable.

SCALENOHEDRONS OF THE ZONE $[10\bar{1}1 : 24\bar{6}1] = [100 : 31\bar{3}]$.

SYMBOL $\frac{h}{k}$.

Extended beyond the limits to be discussed this zone contains several important knot points. Between (100) and $31\bar{3}$) the forms are:

Form	$\begin{cases} p. \\ 100 \end{cases}$	Z $17\cdot1\cdot\bar{3}$	N $13\cdot1\cdot\bar{3}$	$\mathfrak{w}$ $81\bar{3}$	α $51\bar{3}$	c $41\bar{3}$	$\mathfrak{q}$ $31\bar{3}$
Symbol	∞	17	13	8	5	4	3
$v-3$	∞	14	10	5	2	1	0
$\frac{v^1}{2}$	∞	7	5	$\frac{5}{2}$	1	$\frac{1}{2}$	0
N_2	∞	(7)	(5)	$(\frac{5}{2})$	1	$\frac{1}{2}$	0

Referred to N_2 the zone fragment lacks the term 2 and contains the extra forms 17, 13 and 8, the latter of which has been discussed under zone 12. It is noteworthy that these three extra forms were observed on one occurrence, i. e., crystals from Lake Superior, Mich.

Z $(16\cdot4\cdot\bar{2}\bar{0}\cdot15) = (17\cdot1\cdot\bar{3})$. This scalenohedron was observed by Palache [120] on several crystals from Lake Superior. It was described as a somewhat rounded series of planes tending to pass into N $(12\cdot4\cdot\bar{1}\bar{6}\cdot11) = (13\cdot1\cdot\bar{3})$. It marks the intersection of zones $(04\bar{4}3 : 8\bar{4}\bar{4}3]$ and $[11\bar{2}\bar{3} : 40\bar{4}1]$. The form should be regarded as fairly probable.

N $(12\cdot4\cdot\bar{1}\bar{6}\cdot11) = (13\cdot1\cdot\bar{3})$. This scalenohedron was also ob-

118 Beykirch, J., Centralblat. f. Min., **2**, 494 (1901).
119 Sansoni, F.,Giorn. d. Min., **5**, 72 (1894).
120 Palache, loc. cit., Fig. 17.

served by Palache [121] on crystals from Lake Superior. On one combination figured it occurs with $(10\bar{1}1)$ and $(16\cdot4\cdot\bar{2}0\cdot15)$ emphasizing the zone under discussion. The planes were described as smooth and often quite large, evidently furnishing a number of good measurements. The zonal relations are much better than in the previous case and the form should be regarded as well established.

Hypothetical Scalenohedrons. In the above series the missing terms 3 and 2 correspond to the hypothetical forms $(8\cdot4\cdot\bar{1}\bar{2}\cdot7) = (91\bar{3})$ and $(6\cdot4\cdot\bar{1}\bar{0}\cdot5) = (71\bar{3})$ respectively.

$(8\cdot4\cdot\bar{1}\bar{2}\cdot7) = (91\bar{3})$. The pole of this scalenohedron lies in excellent zonal relations with frequent and prominent forms, falling in zones $[40\bar{4}1 : 22\bar{4}3]$ and $[02\bar{2}1 : 41\bar{5}3]$ both of which are well marked. It is noteworthy that the scalenohedron recorded by Flink [122] from Långban, Sweden, falls very close to this hypothetical form. It is possible that it should be substituted for the latter.

$(6\cdot4\cdot\bar{1}\bar{0}\cdot5) = (71\bar{3})$. The pole of this form presents zonal relations which are better than those of the foregoing. It lies in the following well marked zones $[02\bar{2}1 : 31\bar{4}2 : 20\bar{2}1]$, $[40\bar{4}1 : 12\bar{3}2]$ and $[0\bar{1}\bar{1}2 : 21\bar{3}1]$.

SCALENOHEDRONS OF THE ZONE $[41\bar{5}3 : 03\bar{3}1 : 11\bar{2}0] = [40\bar{1} : 44\bar{5} : 10\bar{1}]$

SYMBOL $\frac{h}{k}$.

Developing the first portion of this zone between $(40\bar{1})$ and $(44\bar{5})$ we have:

Form	$\{F:$ $40\bar{1}$	H $20\cdot2\cdot\bar{7}$	$\mathfrak{w}$ $81\bar{3}$	G $12\cdot2\cdot\bar{5}$	ν $41\bar{2}$	$\mathrm{I}\cdot$ $32\cdot15\cdot\bar{2}\bar{3}$	$\mathfrak{E}:$ $42\bar{3}$	$\mathfrak{h}:$ $43\bar{4}$	$\Gamma\cdot$ $44\bar{5}$
Symbol	∞	10	8	6	4	$\frac{32}{15}$	2	$\frac{4}{3}$	1
$v-1$	∞	9	7	5	3	$\frac{17}{15}$	1	$\frac{1}{3}$	0
N_3	∞	(9)	(7)	(5)	3 ..	$(\frac{17}{15})$	1 ..	$\frac{1}{3}$	0

Referred to N_3 this portion of the zone is incomplete and contains the extra forms 10, 8, 6, and $\frac{32}{15}$, of which the second has been discussed under zone 12.

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121 Palache, loc. cit., Figs. 6 and 19.
122 Flink, Arkiv. f. Kemi. Min. Geol., **3**, 55, Fig. 155 and 156 (1910).

H $(63\bar{9}5) = (20\cdot2\cdot\bar{7})$. This scalenohedron was recorded by Whitlock [123] on crystals from West Paterson, N. J. In the combination cited (Type II) this form is present in zone $[0001 : 21\bar{3}0]$ with $(8\cdot4\cdot\bar{12}\cdot5)$, (0001) and $(42\bar{6}1)$. The form also falls in zone $[40\bar{4}7 : 11\bar{2}0]$. It may be regarded as fairly probable.

G $(10\cdot7\cdot\bar{17}\cdot9) = (12\cdot2\cdot\bar{5})$. This scalenohedron was simultaneously observed in 1897 by Butgenbach [124] on crystals from Cumberland, and by Moesz [125] on crystals from Körösmezö, Hungary. In addition to the evidence of two observers, this form presents better zonal relations than the preceding and is referable to normal series N_5. It should be classed as probable.

$I\cdot(17\cdot38\cdot\bar{55}\cdot24) = (32\cdot15\cdot\bar{23})$. This scalenohedron was observed by Palache [126] on crystals from the Lake Superior region of Michigan. The form which was observed twice was developed to an appreciable habit on one crystal but as observed by Palache its occurrence at this locality is exceptional and under ordinary condition the form would be vicinal, probably to $(25\bar{7}3)$.

ϖ $(3\cdot24\cdot\bar{27}\cdot7) = (37\cdot28\cdot\bar{44})$. This scalenohedron was recorded by Morton [127] on crystals from Bamle, Norway. In the combination described by Morton the form occurs with $(32\bar{5}7)$ and $(01\bar{1}0)$ in a fairly well marked zone. It is noteworthy, however, that the hypothetical indices $(4\cdot31\cdot\bar{35}\cdot9) = (19\cdot12\cdot\bar{16})$ fall very close to the position assumed by Morton and offer much better zonal relations. The form is somewhat doubtful.

In the course of the preceding analysis the following tentative substitutions have suggested themselves as offering better zonal relations, as falling in relatively low normal series and as being expressed in simpler Bravais and Miller indices. In every case the difference in φ and ρ value between the questioned and substituted pole is well within the limit of ordinary fair observation.

E $(32\cdot56\cdot\bar{88}\cdot69) = (61\cdot31\cdot\bar{25})$. This scalenohedron was substituted by Palache [128] for the form $(21\cdot35\cdot\bar{56}\cdot44) = (71\cdot58\cdot\bar{47})$, described by him on one crystal from Lake Superior, Mich. Neither form falls in any of the zones discussed, nor are they tied by zonal relations to any of the knot poles of the calcite network. The hypo-

123 Whitlock, H. P., Am. Jour. Sci., **24**, 426 (1907).
124 Butgenbach, H., Soc. Geol. Belg. Ann., **24**, 66.
125 Moesz, G., Fold. Kozlony, **27**, 495.
126 Palache, C., loc. cit.
127 Morton, C., Stockh. Ofvers., **65** (1884).
128 Palache, C., loc. cit., Fig. 5.

Letter	Bravais	Miller	N_2	N_3	N_4	N_5	N_+	Zone intersections
				Zone $[20\bar{2}1 : 02\bar{2}1 : 10\bar{1}0]$				
f	$6\cdot20\cdot\bar{2}\bar{6}\cdot13$	$15\cdot9\cdot\bar{1}\bar{1}$					N_+	$[01\bar{1}1 : 2\cdot8\cdot\bar{1}\bar{0}\cdot3]$, $[16\bar{7}4 : 32\bar{5}1]$
$\mathfrak{E}$	$3\cdot11\cdot\bar{1}\bar{4}\cdot7$	$85\bar{6}$			N_4			$[07\bar{7}5 : 43\bar{7}1]$, $[10\bar{1}1 : 0\cdot11\cdot\bar{1}\bar{1}\cdot1]$
V	$2\cdot8\cdot\bar{1}\bar{0}\cdot5$	$17\cdot11\cdot\bar{1}\bar{3}$					N_+	$[20\bar{2}5 : 01\bar{1}0]$, $[05\bar{5}3 : 23\bar{5}2]$
t	$3\cdot13\cdot\bar{1}\bar{6}\cdot8$	$96\bar{7}$		N_3				$[0\cdot13\cdot\bar{1}\bar{3}\cdot8 : 10\bar{1}0]$
D	$3\cdot8\cdot\bar{1}\bar{1}\cdot4$	$63\bar{5}$		N_3				$[11\bar{2}3 : 27\bar{9}1]$, $[04\bar{4}5 : 24\bar{6}1]$
A	$6\cdot14\cdot\bar{2}\bar{0}\cdot7$	$11\cdot5\cdot\bar{9}$				N_5		$[3\bar{1}\bar{2}1 : 44\bar{8}3]$, $[2\bar{2}01 : 05\bar{5}1]$
g	$16\cdot10\cdot\bar{2}\bar{6}\cdot5$	$47\cdot\bar{1}\cdot\bar{3}1$					N_+	
T	$42\bar{6}1$	$11\cdot\bar{1}\cdot\bar{7}$		N_3				$[40\bar{4}1 : 01\bar{1}0]$, $[50\bar{5}1 : 0\cdot10\cdot\bar{1}\bar{0}\cdot1]$
$\mathfrak{H}$	$9\cdot4\cdot\bar{1}\bar{3}\cdot2$	$8\bar{1}\bar{5}$	N_2					$[11\bar{2}3 : 21\bar{3}1]$, $[40\bar{4}1 : 54\bar{9}1]$
m	$52\bar{7}1$	$13\cdot\bar{2}\cdot\bar{8}$		N_3				$[50\bar{5}1 : 01\bar{1}0]$, $[70\bar{7}1 : 16\bar{7}1]$
				Zone $[1\bar{1}02 : 40\bar{4}7 : 17\bar{8}0]$				
I	$7\cdot17\cdot\bar{2}\bar{4}\cdot8$	$13\cdot6\cdot\bar{1}\bar{1}$			N_4			$[30\bar{3}1 : 03\bar{3}1]$, $[02\bar{2}3 : 24\bar{6}1]$
J	$8\cdot20\cdot\bar{2}\bar{8}\cdot9$	$15\cdot7\cdot\bar{1}\bar{3}$					N_+	$[04\bar{4}3 : 11\bar{2}0]$, $[04\bar{4}5 : 24\bar{6}1]$
i	$9\cdot23\cdot\bar{3}\bar{2}\cdot10$	$17\cdot8\cdot\bar{1}\bar{5}$				N_5		$[0\cdot11\cdot\bar{1}\bar{1}\cdot4 : 11\cdot0\cdot\bar{1}\bar{1}\cdot2]$, $[02\bar{2}1 : 31\bar{4}0]$
Y	$12\cdot32\cdot\bar{4}\bar{4}\cdot13$	$23\cdot11\cdot\bar{2}\bar{1}$					N_+	$[02\bar{2}1 : 21\bar{3}0]$, $[\bar{1}4\bar{3}1 : 40\bar{4}1]$
B	$12\cdot40\cdot52\cdot11$	$25\cdot13\cdot\bar{2}\bar{7}$					N_+	$[05\bar{5}1 : 40\bar{4}1]$, $[20\bar{2}1 : 08\bar{8}1]$
				Zone $[11\bar{2}3 : 13\bar{4}1]$				
W	$3\cdot7\cdot\bar{1}\bar{0}\cdot5$	$63\bar{4}$	N_2					$[3\bar{1}\bar{2}1 : 35\bar{8}4]$
X	$5\cdot13\cdot\bar{1}\bar{8}\cdot7$	$10\cdot5\cdot\bar{8}$			N_4			$[2\bar{2}01 : 04\bar{4}1]$, $[02\bar{2}1 : 51\bar{6}1]$

Letter	Bravais	Miller	N_2	N_3	N_4	N_5	N_+	Zone intersections
Zone $[05\bar{5}1 : 50\bar{5}1 : 01\bar{1}0]$								
S	$15\cdot5\cdot\bar{2}0\cdot4$	$13\cdot\bar{2}\cdot\bar{7}$			N_4			$[50\bar{5}2 : 11\bar{2}0]$, $[05\bar{5}4 : 10\bar{1}0]$
𝔇	$15\cdot4\cdot\bar{1}9\cdot3$	$37\cdot\bar{8}\cdot\bar{2}0$		N_3				$[04\bar{4}3 : 10\bar{1}0]$, $[30\bar{3}1 : 62\bar{8}1]$
𝔈	$25\cdot7\cdot\bar{3}2\cdot5$	$62\cdot\bar{1}3\cdot\bar{3}4$					N_+	
𝔡	$10\cdot3\cdot\bar{1}3\cdot2$	$25\cdot\bar{5}\cdot\bar{1}4$					N_+	$[04\bar{4}1 : 80\bar{8}1]$ $[13\cdot0\cdot\bar{1}3\cdot2 : \bar{1}100]$
Zone $[10\bar{1}1 : 24\bar{6}1]$								
Z	$16\cdot4\cdot\bar{2}0\cdot5$	$17\cdot1\cdot\bar{3}$					N_+	$[04\bar{4}3 : 8\bar{4}\bar{4}3]$ $[11\bar{2}3 : 40\bar{4}1]$
N	$12\cdot4\cdot\bar{1}6\cdot11$	$13\cdot1\cdot\bar{3}$				N_5		$[08\bar{8}7 : 3\bar{1}21]$, $[20\bar{2}1 : 04\bar{4}5]$
Hypothetical scalenohedrons of the zone $[10\bar{1}1 : 24\bar{6}1]$								
	$8\cdot4\cdot\bar{1}2\cdot7$	$91\bar{3}$		N_3				$[11\bar{2}3 : 62\bar{8}1]$ $[02\bar{2}1 : 41\bar{5}3]$
	$6\cdot4\cdot\bar{1}0\cdot5$	$71\bar{3}$	N_2					$[01\bar{1}2 : 21\bar{3}1]$ $[40\bar{4}1 : 08\bar{8}7]$
Zone $[41\bar{5}3 : 03\bar{3}1 : 11\bar{2}0]$								
H	$63\bar{9}5$	$20\cdot2\cdot\bar{7}$					N_+	$[40\bar{4}7 : 11\bar{2}0]$ $[01\bar{1}1 : 30\bar{3}1]$
G	$10\cdot7\cdot\bar{1}7\cdot9$	$12\cdot2\cdot\bar{5}$				N_5		$[01\bar{1}1 : 50\bar{5}1]$ $[01\bar{1}2 : 21\bar{3}1]$
I.	$17\cdot38\cdot\bar{5}\bar{5}\cdot24$	$32\cdot15\cdot\bar{2}3$					N_+	
𝔴	$3\cdot24\cdot\bar{2}\bar{7}\cdot7$	$37\cdot28\cdot\bar{4}\bar{4}$					N_+	$[32\bar{5}7 : 01\bar{1}0]$

thetical scalenohedron $(4\cdot7\cdot\bar{1}\bar{1}\cdot9)$, which lies extremely close to both of the above forms, falls in zone $[11\bar{2}3\cdot13\bar{4}1]$ reducing to $\frac{5}{3}$ in normal series N_4. The latter form, moreover, lies at the intersection of zones $[01\bar{1}2 : 43\bar{7}1]$ and $[4047 : 07\bar{7}2]$. The scalenohedrons $(32\cdot56\cdot\bar{8}\bar{8}\cdot69)$ and $(4\cdot7\cdot\bar{1}\bar{1}\cdot9)$ have the same value for φ and differ in the value of the ρ angle by 1° 15′. In commenting on the form Palache states that the faces were somewhat uneven.

$\mathfrak{F}$ $(12\cdot68\cdot\bar{8}0\cdot35) = (41\cdot29\cdot\bar{3}9)$. This scalenohedron was observed by Schnoor [129] on crystals from Neumark, Germany. The form lies close to the zone $[02\bar{2}1 : 10\bar{1}0]$ and is unrelated to any of the important poles by zone lines. The nearest rational hypothetical form in the zone $[02\bar{2}1 : 10\bar{1}0]$ is $(16\bar{7}3) = (11\cdot8\cdot\bar{1}0)$ which develops to the term $\frac{1}{4}$ in normal series N_4. Although differing somewhat beyond the limits of good observation in position from $(12\cdot68\cdot\bar{8}0\cdot35)$ this latter form presents fair zonal relations. It might possibly be substituted.

Ξ $(18\cdot49\cdot\bar{6}\bar{7}\cdot20) = (35\cdot17\cdot\bar{3}\bar{2})$. This scalenohedron was noted by vom Rath [130] on crystals from Elba. Irby in commenting on it observes that the indices are complex but is unable to find a substitute for it. The pole of the form lies close to $(12\cdot32\cdot\bar{4}\bar{4}\cdot13)$ in zone $[40\bar{4}7: 17\bar{8}0]$ a form which has been ranked as probable in the previous discussion. Another possible substitution would be the hypothetical scalenohedron $(7\cdot20\cdot\bar{2}\bar{7}\cdot8) = (14\cdot7\cdot\bar{1}\bar{3})$ in the zone $[11\bar{2}3 : 13\bar{4}1]$. The zonal relations of both these suggested substitutions are good.

I: $(17\cdot8\cdot\bar{2}\bar{5}\cdot8) = (50\cdot1\cdot\bar{2}\bar{5})$. This scalenohedron is included in Roger's list on the authority of Goldschmidt [131]. The form is listed by Rogers with the note "Observer not known." It lies very close to zone 4 and may be vicinal to $(21\bar{3}1)$, if indeed it is not identical with the latter form.

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129 Schnoor, Wissen. Beil. L., Programm d. Realgym. Z. Zwickau, 16 (1896).
130 vom Rath, G., Pogg. Ann., **158**.
131 Goldschmidt, V., Kryst. Winkeltab.

Positive Scalenohedrons not Previously Included.

L $(22\cdot8\cdot\bar{3}\bar{0}\cdot37) = (89\cdot23\cdot\bar{1})$. This scalenohedron was observed by Thürling [132] on crystals from Andreasberg. In the combination cited by Thürling the form occurs as the inner kernal of a compound crystal of scalenohedral habit, the form in question projecting through the terminating planes $(12\bar{3}5)$ of the outer individual. The planes were described as smooth and brilliant. It is, however, noteworthy that the pole of $(22\cdot8\cdot\bar{3}\bar{0}\cdot37)$ falls very close to that of the common scalenohedron $(31\bar{4}5)$ of zone 4 and may possibly be vicinal to it.

$\mathfrak{A}$ $(7\cdot6\cdot\bar{1}\bar{3}\cdot2) = (22\cdot1\cdot\bar{1}\bar{7})$. This scalenohedron was recorded by Johansson [133] on crystals from Norberg, Sweden. The pole of the form lies at the intersection of several well marked zones, as $[50\bar{5}1 : 8\cdot14\cdot\bar{2}\bar{2}\cdot3]$, $[03\bar{3}1 : 43\bar{7}1]$ and $[20\bar{2}1 : 44\bar{8}1]$ and should be classed as probable.

$\mathfrak{b}$ $(20\cdot11\cdot\bar{3}\bar{1}\cdot15) = (33\cdot2\cdot\bar{9})$
$\mathfrak{a}$ $(37\cdot19\cdot\bar{5}\bar{6}\cdot21) = (38\cdot1\cdot\bar{1}\bar{8})$ These two scalenohedrons were observed by Palache [134] on several crystals from the Lake Superior region of Michigan. They, together with $\mathfrak{w}$ $(7\cdot4\cdot\bar{1}\bar{1}\cdot6)$ as previously discussed, lie in zone $[\bar{1}012 : 21\bar{3}1]$ not $[R : R_3]$ as given by Palache. The good quality of the faces which served to determine these forms and the excellent zonal relations should serve to class both forms as probable.

M $(8\cdot4\cdot\bar{1}\bar{2}\cdot5) = (25\cdot1\cdot\bar{1}\bar{1})$. This scalenohedron like the two last was observed by Palache [135] on one crystal from the Lake Superior region. The planes were relatively large and well developed and the zonal relations very good. The form is well established.

$\mathfrak{B}$ $(10\cdot5\cdot\bar{1}\bar{5}\cdot4) = (29\cdot\bar{1}\cdot\bar{1}6)$. This scalenohedron was observed by Sansoni [136] on crystals from Blaton, Belgium, and by Cesàro [137] on crystals from Rhisnes, Belgium. Cesàro points out that the measurements obtained by Sansoni correspond better to the form $(26\cdot13\cdot\bar{3}\bar{9}\cdot10)$ but emphasizes the fact that these latter indices do not fall in the zones $[50\bar{5}1 : 05\bar{5}2]$, $[50\bar{5}2 : 53\bar{8}2]$ and $[0001 : 21\bar{3}0]$, which zonal rela-

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132 Thürling, G., N. Jahrb. f. Min. B. B., **4**, 327 (1886).
133 Johansson, K., Geol. Fören. Förh., **14**, 49 (1892).
134 Palache, C., loc. cit., Fig. 5.
135 Palache, C., loc. cit., Fig. 9.
136 Sansoni, F., Bull. Ac. Belg., (3), **9**, 287 (1885).
137 Cesàro, G., Ann. Soc. Geol. Belg., **16**, 165 (1889).

tions hold good for the form $(10\cdot5\cdot\bar{1}\bar{5}\cdot4)$. The form should be classed as quite probable.

P $(13\cdot7\cdot\bar{2}\bar{0}\cdot3) = (12\cdot\bar{1}\cdot\bar{8})$. This scalenohedron was observed by Palache [138] on one crystal from the Lake Superior region. The form corresponds to relatively simple indices and lies at the intersection of a number of well marked zones. The form may be regarded as well established.

Φ $(17\cdot8\cdot\bar{2}\bar{5}\cdot3) = (15\cdot\bar{2}\cdot\bar{1}\bar{0})$. This scalenohedron was observed by Cesàro [139] on a number of crystals from Rhisnes. The form was determined from a number of good measurements, and presents excellent zonal relations. It may be regarded as well established.

π $(63\cdot28\cdot\bar{9}1\cdot11) = (55\cdot\bar{8}\cdot\bar{3}\bar{6})$. This scalenohedron was observed by Melczer [140] on crystals from the vicinity of Budapest. The pole of this form does not fall in any well marked zone and lies quite close to that of $(17\cdot8\cdot\bar{2}\bar{5}\cdot3)$. Again, the hypothetical scalenohedron $(23\cdot10\cdot33\cdot4) = (20\cdot\bar{3}\cdot\bar{1}\bar{3})$ lies sufficiently close to $(63\cdot28\cdot\bar{9}1\cdot11)$ to be well within the limits of good measurements, thus:

	φ	ρ
$(63\cdot28\cdot\bar{9}1\cdot11)$	17° 29′	82° 8′
$(23\cdot10\cdot\bar{3}\bar{3}\cdot4)$	17 11	82 7½

From this it would appear that either $(17\cdot8\cdot\bar{2}\bar{5}\cdot3)$ or $(23\cdot10\cdot\bar{3}\bar{3}\cdot4)$, both of which have more rational indices and better zonal relations, could be substituted for $(63\cdot28\cdot\bar{9}1\cdot11)$.

Δ $(70\cdot21\cdot\bar{9}1\cdot13) = (58\cdot\bar{1}3\cdot\bar{3}\bar{3})$. This scalenohedron was observed by Sansoni [141] on two incomplete crystals from Andreasberg. The somewhat irrational indices assigned to this form by Sansoni were evidently derived from the mean values of the measured angles by an emperical application of the derivation formulas. The form does not present good zonal relations and was suspected of being vicinal to $(62\bar{8}1)$. The form is rather doubtful.

U $(61\bar{7}1) = (14\cdot\bar{4}\cdot\bar{7})$. This scalenohedron was recorded by Buttgenbach.[142] The form presents excellent zonal relations and falls in normal series N_3 in the zone developed between $[21\bar{3}1 : 10\bar{1}0] = [20\bar{1} : 2\bar{1}\bar{1}]$. It should be classed as probable.

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138 Palache, C., loc. cit., Fig. 7.
139 Cesàro, G., loc. cit.
140 Melczer, G., Föld. Közlöny, **26**, 79 (1896).
141 Sansoni, F., Atti. d. Lincei Mem., **14** (1884).
142 Buttgenbach, H., Soc. Geol. Belg. Ann., **32**, 86 (1905).

$\mathfrak{D}$ $(21\cdot5\cdot\bar{2}\bar{6}\cdot18) = (65\cdot2\cdot\bar{1}\bar{3})$. This scalenohedron was observed by Whitlock [143] on crystals of the second type from Kelley's Island, Ohio. This form was identified from four series of consistent measurements. It is, however, apparent from a consideration of the zonal relations that the indices $(8\cdot2\cdot\bar{1}\bar{0}\cdot7) = (25\cdot1\cdot\bar{5})$ present a much better agreement than those originally assigned. The pole of the latter form falls at the intersection of the zones $[61\bar{7}5 : 02\bar{2}1]$ and $[4\bar{2}\bar{2}3 : 11\bar{2}1]$. Moreover the calculated angles for $(8\cdot2\cdot\bar{1}\bar{0}\cdot7)$ agree almost as well with observation as do those of $(21\cdot5\cdot\bar{2}\bar{6}\cdot18)$. The indices $(8\cdot2\cdot\bar{1}\bar{0}\cdot7)$ should be substituted for $(21\cdot5\cdot\bar{2}\bar{6}\cdot18)$.

e^3 $(43\bar{7}2) = (13\cdot1\cdot\bar{8})$. This scalenohedron was recorded by Flink [144] on crystals from Långbån, Sweden. As shown on Flink's figure this form lies in the zone $[21\bar{3}1 : 24\bar{6}1 : 01\bar{1}0]$ which developed between the poles $(21\bar{3}1) = (20\bar{1})$ and $(24\bar{6}1) = (31\bar{3})$ gives:

Forms	$20\bar{1}$	$13\cdot1\cdot\bar{8}$	$71\bar{5}$	$51\bar{4}$	$23\cdot5\cdot\bar{1}\bar{9}$	$82\bar{7}$	$31\bar{3}$
Symbol	2	$\frac{13}{8}$	$\frac{7}{5}$	$\frac{5}{4}$	$\frac{23}{19}$	$\frac{8}{7}$	1
$\frac{v - v_1}{v_2 - v}$	0	$\frac{3}{5}$	$\frac{3}{2}$	3	$\frac{15}{4}$	6	∞
$\frac{v^1}{3}$	0	$\frac{1}{5}$	$\frac{1}{2}$	1	$\frac{3}{4}$	2	∞

From which development it will be seen that $(43\bar{7}2)$ fall in normal series N_5. It also lies in zones $[03\bar{3}2 : 10\bar{1}0]$ and $[05\bar{5}2 : 50\bar{5}1]$ both of which are well marked. The form is probable.

e^1 $(14\cdot7\cdot\bar{2}\bar{1}\cdot12) = (47\cdot9\cdot\bar{1}\bar{6})$. This scalenohedron was also recorded by Flink [144] on crystals from the same occurrence as the preceding. The zonal relations of this form are very poor, which coupled with the high Miller indices seem to render the form somewhat doubtful. It is noteworthy that the hypothetical form $(8\cdot4\cdot\bar{1}\bar{2}\cdot7) = (91\bar{3})$ meets the critical requirements of zonal relations and rational Miller indices much better than $(14\cdot7\cdot\bar{2}\bar{1}\cdot12)$, has the same value for the φ angle and differs in ρ value from the latter form by only 12′. It is possible that $(8\cdot4\cdot\bar{1}\bar{2}\cdot7)$ should be substituted.

h' $(16\cdot14\cdot\bar{3}\bar{0}\cdot5) = (12\cdot1\cdot\bar{8})$. This scalenohedron was observed by Flink [145] on crystals from Långbån, Sweden. The form lies in zones $[52\bar{6}1 : 24\bar{6}1]$ and $[50\bar{5}2 : 32\bar{5}1]$ and corresponds to quite simple Miller indices. It is fairly probable.

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143 Whitlock, H. P., S. of M. Quarterly, **31**, 231 (1910).
144 Flink, Arkiv. f. Kemi. Min. Geol., **3**, Fig. 155, 156 (1910).
145 Flink, Arkiv. f. Kemi. Min. Geol., **3**, Fig. 174 (1910).

g' $(21\cdot8\cdot\bar{2}\bar{9}\cdot5) = (55\cdot8\cdot\bar{3}\bar{2})$. This scalenohedron was noted by Flink [146] on crystals from Långbån, Sweden. As shown by the figure cited, the observed planes lie in zone $[50\bar{5}1 : 0\cdot10\cdot\bar{1}\bar{0}\cdot1]$ the form $(50\bar{5}1)$ being present on the combination. The zonal relations of this form in general are not good and it is to be noted that the hypothetical scalenohedron $(25\cdot10\cdot\bar{3}\bar{5}\cdot6) = (22\cdot3\cdot\bar{1}\bar{3})$ which is also in the zone $[50\bar{5}1 : 0\cdot10\cdot\bar{1}\bar{0}\cdot1]$ has simpler Miller indices, better general zonal relations and differs from $(21\cdot8\cdot\bar{2}\bar{9}\cdot5)$ in value of the φ angle by 35′, the ρ angles corresponding to within 2′. The hypothetical scalenohedron $(25\cdot10\cdot\bar{3}\bar{5}\cdot6)$ is a possible substitution.

Negative Scalenohedrons not Previously Included.

Γ $(6\cdot8\cdot\bar{1}\bar{4}\cdot3) = (23\cdot5\cdot\bar{1}\bar{9})$. This scalenohedron was recorded by Sansoni [147] on crystals from Andreasberg. The form marks the intersection of a number of well marked zones and should be classed as probable.

$\mathfrak{r}$ $(4\cdot9\cdot\bar{1}\bar{3}\cdot6) = (23\cdot11\cdot\bar{1}\bar{6})$. This scalenohedron was observed by Schnoor [148] on crystals from Neumark, Sweden. Although not presenting as good zonal relations as the preceding form, this scalenohedron marks the intersection of the zones $[03\bar{3}2 : 10\bar{1}0]$, $[01\bar{1}1 : 45\bar{9}2]$ and $[05\bar{5}3 : 13\cdot0\cdot\bar{1}\bar{3}\cdot2)$. The form should be classed as probable.

$\mathfrak{f}$ $(2\cdot20\cdot\bar{2}\bar{2}\cdot21) = (15\cdot13\cdot\bar{7})$. This scalenohedron was observed by Cesàro [149] on crystals from Rhisnes, Belgium, and the indices $(2\cdot20\cdot\bar{2}\bar{2}\cdot21)$ substituted for $(2\cdot19\cdot\bar{2}\bar{1}\cdot20) = (43\cdot37\cdot\bar{2}\bar{0})$ given in a former paper on the same occurrence. Cesàro points out the fact that the form $(2\cdot20\cdot\bar{2}\bar{2}\cdot21)$ lies at the intersection of the zones $[01\bar{1}1 : 2\bar{1}\bar{1}0]$, $[44\bar{8}3 : 17\cdot8\cdot\bar{2}\bar{5}\cdot3]$ and $[40\bar{4}7 : 08\bar{8}7]$. This would seem to be a good zonal relation, the form, however, lies quite close to $(01\bar{1}1)$ and may possibly be vicinal to the rhombohedron. It is somewhat doubtful.

$\mathfrak{c}$ $(4\cdot20\cdot\bar{2}\bar{4}\cdot17) = (15\cdot11\cdot\bar{9})$. This scalenohedron was noted by Sansoni [150] on crystals from Utö, Sweden. The form was observed in combination with $(08\bar{8}7)$ thus emphasizing the zone $[08\bar{8}7 : 62\bar{8}1]$,

146 Flink, Arkiv. f. Kemi. Min. Geol., **3**, Fig. 156 (1910).
147 Sansoni, F., loc. cit., Fig. 10.
148 Schnoor, loc. cit.
149 Cesàro, loc. cit.
150 Sansoni, F., Giorn. d. Min., **1** (2), 129 (1890).

a well marked zone containing several important forms. Palache [151] also observed this form on several crystals from the Lake Superior region, on one of which the above mentioned zone is quite strongly emphasized. The form also lies in zones [04$\bar{4}$3 : 20$\bar{2}$1] and [05$\bar{5}$4: 40$\bar{4}$1]. It should be classed as well established.

$\mathfrak{d}$ (4·36·$\bar{4}$0·31) = (25·21·$\bar{1}$5). This scalenohedron was also observed by Palache on the same combination noted above, also falling in the zone [08$\bar{8}$7 : 62$\bar{8}$1]. The form also falls at the intersection of the zones [40$\bar{4}$7 : 03$\bar{3}$2] and [10$\bar{1}$1 : 04$\bar{4}$3]. The form should be classed as probable.

R (8·32·$\bar{4}$0·21) = (23·15·$\bar{1}$7). This scalenohedron was noted by Sansoni [152] on one crystal from Andreasberg. The combination figured by Sansoni does not suggest any zonal relations between this scalenohedron and the other forms present on the combination, nor does the form lie in any well marked zone. On the other hand the hypothetical scalenohedron (4·15·$\bar{1}$9·10) = (11·7·$\bar{8}$), the pole of which lies very close to (8·32·$\bar{4}$0·21) marks the intersection of several well defined zones, viz: [01$\bar{1}$2 : 13$\bar{4}$1], [02$\bar{2}$1 : 41$\bar{5}$3], [07$\bar{7}$2 : 41$\bar{5}$6] and [61$\bar{7}$4 : 31$\bar{5}$1]. The agreement between the calculated angles of the hypothetical form and Sansoni's measurements is shown below:

	Measured	Calculated (8·32·$\bar{4}$0·21)	Calculated (4·15·19·10)
10$\bar{1}$0 : *hkil*	55° 18′	55° 44′	55° 7′
01$\bar{1}$0 : "	31 51	31 16	31 17½
08$\bar{8}$7 : "	13 49	13 58	14 47½
10$\bar{1}$1 : "	40 50	40 39	40 30

From the above table it would appear that in 3 out of the 4 angles measured the form (4·15·$\bar{1}$9·10) agrees with the measured angles within the limits of fair observation and in one angle (4·15·1$\bar{9}$·10) is closer to the observed value than (8·32·$\bar{4}$0·21). The form should be classed as doubtful.

C (1·13·$\bar{1}$4·10) = (25·22·$\bar{1}$7). This scalenohedron was observed by Whitlock [153] on crystals from West Paterson, N. J. In spite of the fact that the Miller indices for this form are somewhat irrational the zonal relations between this scalenohedron and other forms present

151 Palache, C., loc. cit., Fig. 12.
152 Sansoni, F., Atti. d. Lincei. Mem., **14**, Fig. 8 (1884).
153 Whitlock, H. P., Am. Jour. Sci., **24**, 426 (1907).

on the combination are fairly good. The pole of the form marks the intersection of the zones $[04\bar{4}3 : 40\bar{4}1]$ and $[06\bar{6}5 : 11\bar{2}0]$. There is, however, a disagreement between the observed and calculated angles which is somewhat greater than the limit of fair observation and the form should be classed as rather doubtful.

K $(1\cdot11\cdot\bar{1}\bar{2}\cdot8) = (76\bar{5})$. This scalenohedron which was observed by Palache [154] on one crystal from the Lake Superior region is regarded by him as very characteristic of the region, occurring on a number of crystals as rounded and broken planes. On the combination cited the pole of this form marks the intersection of the zones $[21\bar{3}1 : 35\bar{8}4]$ and $[3\cdot5\cdot\bar{8}\cdot13 : 02\bar{2}1]$, all the above zone-indicating forms being present. The form may be regarded as established.

ſ $(3\cdot10\cdot\bar{1}\bar{3}\cdot3) = (19\cdot10\cdot\bar{2}\bar{0})$. This scalenohedron was observed by Schaller [155] on two crystals from New Mexico. The combination cited is of prismatic habit, the form $(3\cdot10\cdot\bar{1}\bar{3}\cdot3)$ lying in the zone $[10\bar{1}1 : 01\bar{1}0]$, both zone-indicating forms present. The form, furthermore marks the intersection of the zones $[07\bar{7}2 : 33\bar{6}1]$, $[05\bar{5}1 : 30\bar{3}1]$ and $[3\bar{2}\bar{1}1 : 34\bar{7}2]$. It should be classed as probable.

ℭ $(3\cdot61\cdot\bar{6}\bar{4}\cdot26) = (31\cdot28\cdot\bar{3}\bar{3})$. This scalenohedron was observed by Cesàro [156] on crystals from Rhisnes, Belgium. The Miller indices corresponding to this form are quite complex and the zonal relations poor. Moreover the form was observed as a multiple series of planes producing a number of reentrant angles, a condition unfavorable to exact measurement. The form should be classed as doubtful.

ɯ $(16\cdot59\cdot\bar{7}\bar{5}\cdot17) = (36\cdot20\cdot\bar{3}\bar{9})$. This scalenohedron was recorded by Gonnard [157] on crystals from Couzon, Rhône, France. Like the preceding form this scalenohedron does not reduce to very rational Miller indices, nor does it fall in any well marked zone. The pole of the hypothetical scalenohedron $(9\cdot35\cdot\bar{4}\bar{4}\cdot10) = (21\cdot12\cdot\bar{2}\bar{3})$ lies within 31′ of φ angle and within 2′ of ρ angle of that of $(16\cdot59\cdot\bar{7}\bar{5}\cdot17)$. The above hypothetical form also marks the intersection of the zones $[07\bar{7}2 : 10\bar{1}0]$, $[31\bar{4}2 : 13\bar{4}1]$, $[30\bar{3}1 : 05\bar{5}1]$ and $[\bar{1}4\bar{3}1 : 16\cdot7\cdot\bar{2}\bar{3}\cdot3]$. It is possible that the indices $(9\cdot35\cdot\bar{4}\bar{4}\cdot10)$ should be substituted for $(16\cdot59\cdot\bar{7}\bar{5}\cdot17)$.

ƀ $(3\cdot16\cdot\bar{1}\bar{9}\cdot2) = (8\cdot5\cdot\bar{1}\bar{1})$. This scalenohedron was observed by

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154 Palache, C., loc. cit., Fig. 13.
155 Schaller, W. T., Zeit. f. Kryst., **44**, 325.
156 Cesàro, G., loc. cit., page 272, Fig. 52.
157 Gonnard, F., Bull. Soc. fr. Min., **20**, 330 (1897).

Melczer [158] on crystals from Budapest. Both the Miller indices and the good zonal relations of this form should class it as well established.

δ $(1\cdot13\cdot\bar{1}4\cdot1) = (16\cdot13\cdot\bar{2}6)$. This scalenohedron was observed by Sansoni [159] on crystals from Freiberg. In spite of the extreme steepness of this form the zonal relations are fairly good; the pole of $(1\cdot13\cdot\bar{1}4\cdot1)$ marks the intersection of the zones $[10\bar{1}1 : 01\bar{1}0]$, $[4\bar{2}\bar{2}1 : 33\bar{6}1]$ and $[51\bar{6}1 : 44\bar{8}1]$. The form should be classed as fairly probable.

$\mathfrak{r}$ $(3\cdot15\cdot\bar{1}8\cdot2) = (23\cdot14\cdot\bar{3}\bar{1})$. This scalenohedron was noted by Whitlock [160] on crystals from two localities in the New York State, i. e., Union Springs and Rondout. In spite of the steepness of this form and the fact that the Miller indices corresponding to it are somewhat irrational the zonal relations are fair. The pole of the form falls at the intersection of the zones $[54\bar{9}1 : 27\bar{9}1]$, $[31\bar{4}2 : 01\bar{1}0]$ and $[40\bar{4}1 : 33\bar{6}1]$. Like the preceding, this form should be classed as fairly probable.

$\mathfrak{T}$ $(6\cdot13\cdot\bar{1}9\cdot4) = (29\cdot11\cdot\bar{2}\bar{8})$. This scalenohedron was observed by Whitlock [161] on crystals from Kelley's Island, Ohio. This form, which was observed on both types from this locality, was identified from a good series of measurements taken from smooth and well developed planes. The form lies in the zone $[8\cdot8\cdot\bar{1}6\cdot3 : \bar{8}\cdot16\cdot\bar{8}\cdot3]$ a relation which was checked by observation, and also marks the intersection of the zones $[3\bar{3}02 : 01\bar{1}0]$ and $[0\cdot13\cdot\bar{1}\bar{3}\cdot4 : 10\bar{1}0]$. The form may be regarded as probable.

h^5 $(6\cdot13\cdot\bar{1}9\cdot8) = (11\cdot5\cdot\bar{8})$. This scalenohedron was observed by Flink [162] on crystals from Utö, Sweden. The combination as drawn by Flink shows the planes of this form lying in zone with those of $(5\cdot12\cdot\bar{1}7\cdot8)$, that is in zone $[5\cdot12\cdot\bar{1}7\cdot8 : \bar{5}\cdot17\cdot\bar{1}2\cdot8]$ a relation which is proved untrue when tested by zonal equations. Moreover the pole of $(6\cdot13\cdot\bar{1}9\cdot8)$ lies close to the intersection of Z_6 Z_9 which intersection is marked by the pole $(25\bar{7}3)$. The form appears to be somewhat doubtful.

h_6 $(5\cdot12\cdot\bar{1}7\cdot8) = (10\cdot3\cdot\bar{7})$. This scalenohedron was observed by Flink [162] on the same combination as the preceding. The same objection to the form as drawn as that given under $(6\cdot13\cdot\bar{1}9\cdot8)$ applies

158 Melczer, G., Föld. Közlöny, **26**, 79 (1896).
159 Sansoni, F., Giorn. Min., J. 72 (1894).
160 Whitlock, H. P., N. Y. State Mus. Mem., **13**, Plate XVIII, Fig. 7 and Plate XXVI, Fig. 1 (1910).
161 Whitlock, H. P., S. of M. Quarterly, **31**, 231 (1910).
162 Flink, Arkiv. f. Kemi. Min. Geol., **31**, 174 (1910).

in this instance. The pole of $(5\cdot12\cdot\bar{1}\bar{7}\cdot8)$ lies at the intersection of the zones $[51\bar{6}4 : 0\cdot11\cdot\bar{1}\bar{1}\cdot4]$ and $[11\bar{2}3 : 13\bar{4}1]$ both of which are well defined. The form is considerably more probable than the preceding.

General Conclusions.

In reviewing the foregoing discussion several facts are brought out with more or less clearness.

1.— The forms whose poles are marked by three zone intersections are those which a student of the species would recognize as common forms. An apparent exception to this statement is to be found in the negative rhombohedron $(05\bar{5}1)$. The expression "apparent" is used because in the experience of the writer this form is far more common on calcite crystals than is usually conceded.

2.— It will be noted that the zone of the second order pyramids Z_2 is marked by a fair number of zone intersections and that where the poles of the second order pyramids, particularly those of the $(11\bar{2}3)$, $(22\bar{4}3)$, $(44\bar{8}3)$ etc., series fall in other zones they occur in relatively low normal series. It would be seen that this series of pyramids, which has been regarded as rare up to a comparatively recent date [163] is considerably more common than has been hitherto recognized. This again coincides with observation, the pyramid $(8\cdot8\cdot\bar{1}\bar{6}\cdot3)$ having been the dominant habit in at least four new occurrences of calcite falling under the writer's notice within the last five years.[164]

3.— That portion of the principal zone, Z_4, lying between the poles p $(10\bar{1}1)$ and P: $(32\bar{5}1)$ shows a completeness with respect to recorded forms which argues strongly against subsequent additions to this part of the zonal field. Especial care should be exercised by future observers and tentative interpolated forms should be strictly criticized and if possible referred to established indices.

4.— Although zones Z_5, Z_6 and Z_7 are strongly marked there are several gaps in normal series N_3 some of which will undoubtedly be filled by future observation. The investigator of calcite should keep these well in mind and weigh carefully the data concerning forms whose poles fall sufficiently near them to be within the limits of goniometrical measurement.

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163 See Penfield and Ford, Am. Jour. Sci., **10**, 238 (1900).

164 These occurrences are Kelley's Island, Wisby and two undescribed Canadian localities.